European Commission

JRC SCIENTIFIC AND POLICY REPORTS

Workshop Proceedings: Safe and Efficient Shale Gas Exploration and Production

Best available technologies and R&D projects for Europe

Amsterdam, 7-8 March 2013
Enlargement and Integration Workshop

EDITED BY ARNE ERIKSSON, LUCA GANDOSSI, PETER ZENIEWSKI

2013

Report EUR 25990 EN

Joint Research Centre

European Commission
Joint Research Centre
Institute for Energy and Transport

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This publication is a Reference Report by the Joint Research Centre of the European Commission.

JRC82564

EUR 25990 EN

ISBN 978-92-79-30642-6 (pdf)

ISSN 1831-9424 (online)

doi: 10.2790/77620

Luxembourg: Publications Office of the European Union, 2013

WORKSHOP PROCEEDINGS:
SAFE AND EFFICIENT SHALE GAS EXPLORATION AND PRODUCTION:

7-8 MARCH 2013
AMSTERDAM, THE NETHERLANDS

ENLARGEMENT AND INTEGRATION WORKSHOP

A REPORT BY THE ENERGY SECURITY UNIT

OF THE

EUROPEAN COMMISSION'S JOINT RESEARCH CENTRE

Edited by
Arne Eriksson, Luca Gandossi, Peter Zeniewski
(European Commission, JRC, Energy Security Unit)

Foreword

The European Commission's Joint Research Centre – Energy Security Unit, in cooperation with the Directorate-General for Energy, organised an Enlargement and Integration (E&I) Workshop on "Safe and Efficient Shale Gas Exploration and Production: Best available technologies and R&D projects for Europe". The workshop took place in Amsterdam, the Netherlands, on 7-8 March 2013.

The main objectives of the workshop were twofold: to present and discuss on-going and planned European research, development and demonstration projects; and to explore the interest in, and viability of a European Platform or Network for Shale Gas Development. The participants consisted of, in equal parts, representatives from industry, geological surveys, academia and European Commission officers, involved in European unconventional oil and gas development and research.

Presentations were given on European research, development and demonstration projects covering a broad spectrum of technical, social and environmental issues related to safe and efficient shale gas development in Europe. Discussions on state of the art, best practices, R&D results and gaps as well as possible needs for demonstration projects were conducted, as well as the need of bringing together industry and research representatives in a structured dialogue, sharing information, reviewing R&D needs and communicating with policy makers.

This report summarises the main conclusions from the Workshop and includes the presentations that were given by the invited Speakers.

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1 Workshop scope and objectives

1.1 Objectives

The two main objectives of the workshop were

- To present and discuss on-going and planned European research, development and demonstration projects;
- To explore the interest in, and viability of a European Platform for Shale Gas Development.

During the workshop, technical, social and environmental issues related to safe and efficient shale gas production were discussed and the viability of a European platform on shale gas was explored.

1.2 Target Groups

The target audience were industry and research representatives involved in European unconventional oil and gas development and research.

1.3 Description

Firstly, the workshop heard presentations on European research, development and demonstration projects covering a broad spectrum of technical, social and environmental issues related to safe and efficient shale gas development in Europe.

Each session was followed by a discussion on state of the art, best practices, R&D results and gaps as well as possible needs for demonstration projects also with a view to enhance public acceptance.

Secondly, the JRC launched a discussion on the need and viability a European platform (or network) for shale gas development, with the main goal to contribute to the safe and efficient shale gas development, by bringing together industry and research representatives in a structured dialogue, sharing information, reviewing R&D needs and communicating with policy makers. The workshop discussed this platform proposal, alongside other on-going initiatives, in order to evaluate its viability and the best way forward.

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2 Workshop Agenda

DAY 1 – 7 March 2013

08:30 – 09:00: Registration

09:00 – 09:10: Welcome and opening of the workshop (*Marcelo MASERA, Head of ES Unit, JRC IET*)
09:10 – 09:25: Opening remarks by DG Energy (*Michael SCHUETZ, DG Energy*)
09:25 – 09:35: Workshop agenda, objectives and expected output (*Arne ERIKSSON, JRC IET*)

SESSION 1 - **NATIONAL and INDUSTRY INITIATIVES**

09:35 – 10:15: Presentations (20 minutes each):

- *Chevron's shale gas research and development: key themes, key questions and key partnerships* (*Steve GARRETT, Chevron*)
- *Current situation of shale gas exploration in Spain* (*Jorge LOREDO, University of Oviedo*)

SESSION 2 - **BELOW SURFACE**

10:15 – 10:55: Presentations (20 minutes each):

- *UK shale gas, what we know, what we don't know* *(Nick RILEY, British Geological Survey)*
- *QA/QC aspects of hydraulic and dry-fracturing technologies* *(Jan HUPKA, Gdansk University of Technology*)

11:15 – 11:35: Presentation:

- *On the sustainable development of shale resource plays* (*Brian HORSFIELD, Helmholtz Centre Potsdam*)

11:35 – 12:00: Discussion – Session 2

SESSION 3 - **ABOVE SURFACE**

12:00 – 13:00: Presentations (20 minutes each):

- *Modelling of large scale field developments* *(Mathias MITSCHANEK, Mining Univ. of Leoben)*
- *Land use for shale gas and infrastructure* *(Peter ZENIEWSKI, JRC IET)*
- *Accelerating the economic appraisal and development of European shale liquids - possible R&D pathways* *(Ruud WEIJERMARS, TU Delft*)

14:00 – 14:25: Discussion – Session 3

SESSION 4 - **RISK ASSESSMENT**

14:25 – 15:25: Presentations (20 minutes each):

- *IRGC draft risk governance guidelines* *(Marie-Valentine FLORIN, IRGC)*
- *DNV Recommended Practice on Risk Management* *(Lars SØRUM, DNV)*
- *Shale resources: assessing practices and risk, and environmental and social considerations* (*Paul KRISHNA, XTO Energy*)

15:25 – 15:50: Discussion– Session 4

SESSION 5 – **ENVIRONMENT**

16:10 – 16:50: Presentations (20 minutes each):

- *Environmental Aspects of Hydraulic Fracturing Treatment Performed on the Łebień LE-2H Well* *(Monika KONIECZYNSKA, PGI)*
- *Advanced technologies for water and solid waste treatment in shale gas production* *(Jan HUPKA, Gdansk University of Technology)*

16:50 – 17:15: Discussion– Session 5

DAY 2 – 8 March 2013

SESSION 6 - **DEMONSTRATION PROJECTS AND PUBLIC ACCEPTANCE**

09:00 – 10:00: Presentations (20 minutes each):

- *Community relations in shale gas development. Examples of good practices from Poland* *(Tomasz GRYZEWSKI, Talisman)*
- *Good practices on social and community engagement* *(Nikolaas BAECKELMANS, ExxonMobil)*
- *Chemical disclosure of hydraulic fracturing fluids: an industry response* *(Malcolm RICE-JONES, OGP)*

10:00 – 10:30: Discussion– Session 6

SESSION 7 - **JOINT INITIATIVES AND EUROPEAN PLATFORM**

10:50 – 11:30: Presentations (20 minutes each):

- *A Ukrainian platform for shale gas: Kyiv Unconventional Gas Institute* *(Anton ANTONENKO, DiXi Group)*
- *European Platform on Shale Gas* *(Arne ERIKSSON & Michael SCHUETZ)*

11:30 – 12:30: Discussion– Session 7

12:30 – 13:00: Closing remarks: workshop conclusions and the way ahead

(*Marcelo MASERA, Head of ES Unit, JRC IET*)

3 Participants list

	NAME	INSTITUTION	COUNTRY
1	Anton **ANTONENKO**	DiXi group Ukraine	Ukraine
2	Nikolaas **BAECKELMANS**	ExxonMobil	United Kingdom
3	Andrei **BALA**	National Institute for Earth Physics	Romania
4	Ricardo **BOLADO-LAVIN**	European Commission - DG JRC	The Netherlands
5	Rachel **BONFANTE**	OGP - Oil & Gas Producers	Belgium
6	Didier **BONIJOLY**	Bureau de Recherches Géologiques et Minières (BRGM)	France
7	Peter **BRITZE**	Geological Survey of Denmark and Greenland	Denmark
8	Iuliana **CHIDU**	Romanian Ministry of Environment and Climate Change	Romania
9	Uwe **DANNWOLF**	RiskCom GmbH	Germany
10	Arne **ERIKSSON**	European Commission - DG JRC	The Netherlands
11	Marie-Valentine **FLORIN**	International Risk Governance Council (IRGC)	Switzerland
12	Juraj **FRANCU**	Czech Geological Survey	Czech Republic
13	Luca **GANDOSSI**	European Commission - DG JRC	The Netherlands
14	Juan **GARCÍA**	Ente Vasco de la Energía (EVE)	Spain
15	Steve **GARRETT**	Chevron Energy Technology Company	United Kingdom
16	Tomasz **GRYŻEWSKI**	Talisman Energy Polska	Poland
17	Anke **HECKELSMUELLER**	RiskCom GmbH	Germany
18	Brian **HORSFIELD**	German Research Centre for Geosciences (GFZ)	Germany
19	Jan **HUPKA**	Gdansk University of Technology	Poland
20	Sigita **JURKYNAITĖ**	Embassy of Lithuania	Lithuania
21	Daria **KARASALIHOVIĆ SEDLAR**	Faculty of Mining Geology and Petroleum Engineering	Croatia
22	Monika **KONIECZYŃSKA**	Polish Geological Institute	Poland
23	Paul **KRISHNA**	XTO Energy	United States of America
24	Stefan **LADAGE**	Geozentrum Hannover	Germany
25	Florence **LIMET**	European Commission - DG ENV	Belgium
26	Øystein **LIND**	Statoil - EU Affairs Office	Belgium
27	Jorge **LOREDO**	E.T.S. Ingenieros de Minas - Universidad de Oviedo	Spain
28	Marcelo **MASERA**	European Commission - DG JRC	The Netherlands
29	Juozas **MOCKEVICIUS**	Lithuanian Geological Survey	Lithuania
30	Radoslav **NAKOV**	Geological Institute of BAS	Bulgaria
31	Malcolm **RICE-JONES**	OGP - Oil & Gas Producers	United Kingdom
32	Nicholas **RILEY**	British Geological Survey	United Kingdom

	NAME	INSTITUTION	COUNTRY
33	Carlos **ROSA**	Laboratório Nacional de Energia e Geologia	Portugal
34	Michael **SCHUETZ**	European Commission - DG ENER	Belgium
35	AMBASSADOR Darius **SEMAŠKA**	Embassy of Lithuania	Lithuania
36	Lars **SØRUM**	DNV	United Kingdom
37	Mathias **MITSCHANEK**	Montanuniversität Leoben	Austria
38	Ruud **WEIJERMARS**	Delft University of Technology	The Netherlands
39	Angeles **YACKOW**	GDF SUEZ E&P International	France
40	Namik **YALÇIN**	Istanbul University, Engineering Faculty	Turkey
41	Peter **ZENIEWSKI**	European Commission - DG JRC	The Netherlands

4 Summary of session 1: NATIONAL and INDUSTRY INITIATIVES

Steve Garrett (Chevron Energy Technology Company) gave a presentation on Chevron's shale gas research and development. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- It is too early to tell with certainty what recoverable resources exist in the UK.
- Regarding Core Area Identification, it appears the current technologies can be adapted for shale characterization (with adjustment or modifications as appropriate). Integration of data is key to understanding and interpreting the state of nature for shale formation. The problem with core area identification is permitting/regulation bottlenecks.
- Water management. The focus of water management associated with shale development in the long run is to achieve operational sustainability by reducing environmental impacts by combining efforts towards (a) minimum use of fresh water source; (b) optimizing source selection and (c) maximizing re-use of produced water.
- Footprint minimization. The goal is to minimize footprint for sustainable shale operations in the future. This is addressed by R&D efforts in optimizing facility designs, examining various alternatives for fuel use, testing emerging compact / mobile processing units, and minimizing environmental impacts (noises, emission).
- Chevron has been working with Leeds University to investigate the physics of flow and other technological facilitation. Some examples of R&D include the patent-pending removable water tanks, which contribute to a reduced surface footprint. Chevron is also funding peer-reviewed science at Durham but this raises the question of neutrality and ethics.
- One of the main contributions that a European R&D platform/network could make would be to establish environmental baselines and to foster harmonization of data.

Jorge Loredo (Oviedo University) gave a talk that focused on the shale gas potential in Spain and reported some preliminary data (possibly 72 billion cubic feet over 220,000 km^2). The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- Spain is very dependent in terms of energy from abroad and the country imports almost 100% of oil and gas consumed; natural gas in 2010 constituted a 24,5% of primary energy in Spain, whereas it was only 2% in 1985.
- The country is currently involved in an exploration phase for unconventional gas resources, where the required permits have as objectives an evaluation of gas resource and the technical, economical and environmental viability of its extraction and subsequent production.

- Recently, some unconventional gas exploration permits have been adjudicated or are in process in different parts of the country, mainly in Cantabria, north of Castilla y León and País Vasco. These permits allow research but not extraction nor production of the resource.
- The confirmation of both shale gas potential and technical-economical and environmental viability of those reserves will mean a transformation of the Spanish economy.
- Exploration activities. There are several companies involved in the development of different shale gas projects in the country. The companies are involved in an intense hydrocarbons research that includes seismic data acquisition and exploratory drills in order to value the potential to obtain research permits. The Cantabrian basin has become an interesting area for the exploration of unconventional gas resources.
- Social Pressure. Social pressure from different social stakeholders in Spain has managed to stop some of the research permits acquired, such as Arquetu, in Cantabria.
- Finally, the recent approval of a law by the Government of Cantabria to prohibit hydraulic fracking in that region both for exploration and exploitation activities was emphasized. According to the regional government, this measure will be in place until it is showed that the technique is not dangerous for health and the environment.

5 Summary of session 2: BELOW SURFACE

Nick Riley (British Geological Survey) gave a talk on the shale gas possibilities in the UK, in particular focusing on the characteristics of the Bowland Shales. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- In the UK, exploration drilling for shale gas is in its very early stages and has targeted the "Bowland Shales", in the Lower Carboniferous of NW England.
- The geology of this region was reviewed. It has one of the thickest Lower Carboniferous sequences in the world. A complex interplay of factors has resulted in complex changes in thickness and lithology.
- Early estimates of the resource (gas in place, possible recovery factors, etc.) have relied heavily on comparisons with experience from N. America (e.g. BGS 2010), and the validity of such analogies is not clear.
- Further exploration drilling and testing is essential to understand whether the Bowland Shale play will be a prolific shale gas resource or not.
- Drilling access is going to more problematic than in the United States, due to regulatory and spatial constraints
- Locating sweet spots will be essential to make the resource economically recoverable, and to enable this a sophisticated geological understanding of the play will be required. For instance, drilling companies could potentially save a lot of money by taking and analysing cores early in the exploration stage.

Prof. Jan Hupka (GUT – Gdansk University of Technology) gave a talk on quality assurance and quality control aspects of hydraulic and dry-fracturing technologies. The presentation can be found here.

The main point of the presentation and the ensuing discussion were as follows:

- The most frequently-used argument against exploration and production of shale gas is the safety of people and the environment. Prof. Hupka challenged this statement by pointing out that using QA/QC rules, safety does not need to be compromised when using hydraulic fracturing for shale gas production.
- A technology ("dry-fracturing") was presented for fracturing the shales without using fluids. This is under development at GUT.
- On 19 February the "European Shale Gas Arguments Map" containing the pros and cons of shale gas production in EU Member States was launched in the European Parliament. The map provides the foundation for open discussion and helps the user make a balanced judgement. Prof. Hupka discussed the Argument Map from a Polish perspective.
- A table was presented comparing hydraulic fracturing with dry fracturing and showing the potential benefits of the latter (see this slide and the 3 following ones)

Prof. Brian Horsfield (GFZ German Research Centre for Geosciences) gave a presentation focusing on the sustainable development of shale gas resources. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- There are great opportunities for scientific and technological breakthroughs concerning the formation and extraction of shale gas. Technology has to be tailored to the geology, and the geology is very difficult to predict, since no two shales are the same.
- Improved fracturing and production methods, as well as new integrated geological models are at the forefront of GFZ's research efforts.
- Transparency in operations (monitoring) and staying in close touch with all stakeholders are of paramount importance if technologically proven reserves are to be exploited.
- Credibility issues associated with industry-sponsored academic research were discussed. Prof. Horsfield recalled the example of Durham university appointing an independent science board (that included members of NGOs) to keep scientific accountability. Of all the players involved, large research organizations uniquely stand out as the ideal foundation for honest brokering, including fact-based debate.
- The need for an EU database to facilitate geological knowledge in Europe was discussed.

6 Summary of session 3 ABOVE SURFACE

Mathias Mitschanek (Mining University of Leoben) gave a presentation on the modelling of large-scale shale gas field developments. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- A system dynamics model for large scale field developments of shale gas using GIS data was introduced, its boundaries and parameters were described and some technical and economic scenarios investigated.
- The objectives are multiple, for instance to study field development dynamics in specific areas, to compare different field development strategies, to analyse environmental impact and to define strategies to minimize it, etc.
- Some preliminary findings for the modelling of the region of Lower Saxony in Germany were discussed.

Peter Zeniewski (European Commission, JRC, Institute for Energy and Transport) gave a presentation focusing on land use for shale gas and infrastructure. The presentation can be found here.

The main point of the presentation and the ensuing discussion were as follows:

- A regulatory perspective for land requirements for shale gas was presented.
- Key 'spatial' differences between US/EU were discussed, highlighting the fact that these are often claimed to explain why shale gas will be much more difficult to develop in Europe as compared to the US: (1) the unique nature of property rights in the United States create a financial incentive for private owners to allow the disruptions associated with shale operations; (2) the population is used to proximity to oil and gas operations, whereas onshore oil and gas operations are uncommon in Europe.
- In Europe, the surface-level challenges of shale gas need to reconcile the interests of three broad sets of actors: state actors, societal actors and market actors. Each actor has different expectations, which need to be adequately addressed by a robust regulatory regime.
- From a spatial perspective, this requires coverage of a wide number of different issues ranging from the protection of air, water and land to a clear and robust concession-granting policy. In many countries in Europe, there are laws already in place regarding these issues. The challenge is to determine what additional regulation is needed to govern the unique features of shale gas extraction.
- A case study for Poland's market and infrastructure needs for shale gas was presented.
- One of the goals of the R&D platform/network proposed by the JRC can be to inform regulators and authorities about the optimal centralised drilling programme that minimises surface disturbance by reducing redundant infrastructure and rationalising the placement of wells.

Ruud Weijermars (TU Delft) gave a talk that focused on the possible R&D pathways for enhancing the economic appraisal and the development of European shale liquids. The presentation can be found here.

The main point of the presentation and the ensuing discussion were as follows:

- Ruud Weijermars discussed the need for governance of the industry and argued that more accurate resource reporting is needed (as some companies regularly over-state their gas shows).
- The need for precision fracturing and for the generation of more accurate stress maps in order to create well-positioned wells was emphasized.
- Ruud Weijermars offered several interesting recommendations (consolidated as below):
    - Appoint an EU Shale Resource Ambassador: promote societal legitimacy shale resources, with main driver being energy security
    - Regulate Governance Issues: allocation of regional benefits and communicating with the public, reserves reporting guidelines and research access, operational monitoring issues, environmental issues such drinking water, etc., development of standards and sharing of best practices on risk management
    - Model the regional & energy system for gas & oil price elasticity: prevent price collapse as it happened in the US (pipeline capacity shortage & overproduction)
    - Map out Geoscience & Petrophysics (European database): maturity windows for all major shale plays; regional in-situ stress maps: seismic risk zones: identify prime shale development regions (based on above plus surface conditions: markets, pipelines, local support levels, etc.)
    - Improve engineering practices & tools: stimulate well technology innovation (pilot projects); improve fracturing efficiency; boost well productivity by intelligent stimulation
    - Improve economic models & tools: realistic field development scenarios (infrastructure); well rollout rate & architecture; optimize return on investment

7 Summary of session 4: RISK ASSESSMENT

Marie-Valentine Florin (International Risk Governance Council - IRGC) gave a presentation on the IRGC draft risk governance guidelines. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- The International Risk Governance Council is currently carrying out work to develop "risk governance guideline for unconventional gas development" that would have relevance for various countries and context situations.
- These guidelines are being elaborated after a comprehensive literature review, interviews with experts, and a multi-stakeholder workshop held in November 2012. They aim at addressing opportunities and risks for policymakers, regulators and industry.
- Further to the need to mitigate the technical, environmental, social and economic risks involved in the industrial process, IRGC is keen to highlight the importance to involve and communicate with all stakeholders (in particular local communities).
- A crucial factor is legitimacy and trust so as to reduce perceived risks.

Lars Sørum (DNV) gave a presentation on the DNV Recommended Practice on Risk Management. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- Managing the risk associated with shale gas operations by applying risk management frameworks supported by independent verification will provide a "social licence to operate".
- The use of recommended practices was addressed, and a summary of DNV's recommended practice in a life cycle perspective was included.
- The importance of baseline surveys was highlighted.
- The presentation showed how the operator could manage their total risk by discussing different types of risk and risk management frameworks.
- DNV's recommended practice is not aimed at replacing existing legislation but discusses perceived risks and cumulative probabilities or consequences of potential shale gas development.

Paul Krishna (XTO Energy) gave a presentation on assessing practices and risk for shale resources, including environmental and social considerations. The abstract can be found here and the presentation here.

The main point of the presentation and ensuing discussion were as follows:

- Paul Krishna presented the view that the safe and efficient development of shale gas resources by a company depends on two important elements: (1) a

responsible operations philosophy and (2) an established and effective risk management approach.

- The view was given that it is important to assess the risk based on real data and mitigate them (when significant) to lower levels.
- Risks should be assessed and managed by the probability and consequence rather than as absolute worst case scenarios.
- Peer reviewed technical studies exist, enabling companies to apply this risk management framework to water management, groundwater protection/well integrity, air quality and emissions, induced seismicity, and hence address social and community concerns.
- ExxonMobil risk management framework was presented as a responsible approach for progressing shale development.
- FracFocus, the voluntary disclosure by the industry of chemicals used in the fracturing process, was discussed.

8 Summary of session 5: ENVIRONMENT

Monika Konieczynska (Polish Geological Institute) gave a presentation on undertaking an environmental impact assessment on the Łebień well near Gdansk, Poland. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- Detailed studies of changes in environmental conditions were carried out in area of the first horizontal exploratory well in Poland, in which the Lane Energy company performed full-scale hydraulic fracturing in the middle of 2011.
- The team of 30 specialists from several Polish research institutes examined environmental conditions before, during and after the hydraulic fracturing. The studies were comprehensive, covering air, soil gas, surface water and usable groundwater, soil, noise level and induced seismicity. A special attention was paid to the presence of methane, the major component of natural gas, and of radon.
- The studies did not show any changes in the natural environment which could be linked with the hydraulic fracturing. No air pollution due to work of power generators was noticed. Neither methane nor radon concentration increase were detected. Seismic stations did not record any quakes during the time of fracturing, except tremors associated with seismic activity in South-East Asia. Also analyses of water from the local creek and 9 water wells did not show any changes in chemical composition as found before the hydraulic fracturing. Only noise level turned to be intensified from time to time but only in the direct proximity of the well pad equipment.
- The use of large quantities of water in hydraulic fracturing operations did not cause any depletion in groundwater resources in the Łebień well area. Water was being collected constantly for several months in quantities consistent with the water rights permit and stored in leak-proof reservoirs.

Jan Hupka (Gdansk University of Technology) gave a presentation on advanced technologies for water and solid waste treatment in shale gas production. The presentation can be found here.

The main point of the presentation and the ensuing discussion were as follows:

- The goal of GUT research is to point out the areas which, through strategically focused R&D, will allow Poland to become an important participant in the discovery and production process, far beyond geological resource owner and production labor supplier.
- Examples of some of the work being carried out include using photocatalysis as a prospective technology that may be used to better manage wastewater during fracking. A photocatalytic reaction can be defined as a chemical reaction induced by photoabsorption of a solid material, or photocatalyst, which remains unchanged during the reaction. Photocatalytic decomposition of pollutants in gas and liquid phases can target several pollutants in wastewater and air purification

processes. In this context a spinning fluids reactor is seen as an important technology that can be developed to better manage and reduce the environmental footprint of drilling activities.

- GUT is developing an automatic mobile equipped with two 600 dm3and one 1200 dm3 cylindrical tanks and several new type SFR in series or in parallel.

9 Summary of session 6: DEMONSTRATION PROJECTS AND PUBLIC ACCEPTANCE

Tomasz Gryzewski (Talisman Energy) gave a presentation on Polish good practices in the area of community relations in shale gas development. The abstract can be found here and the presentation here.

The main point of the presentation and the ensuing discussion were as follows:

- In partnership with San Leon Energy, Talisman holds three exploration concessions in the Baltic Basin of Poland, with a total area of over 2500 sq. km. Three concessions provide Talisman with an exposure to a range of geological objectives, thus diversifying the high level of risk associated with exploration in a complex region with sparse geological data.
- Talisman has several initiatives to create public awareness and eventual acceptance of shale gas exploration activities in Poland. Stakeholder engagement is a key part of the company's Shale Principles. Examples include the Social Impact Assessment study of publicly available documents – municipalities, villages, regions development plans, macro economies of the region, any possible characteristics of the region, village nearby to land leases and exploratory drilling – with local visits and face–to face talks with identified influential individuals – either formal (government) and informal (local businessmen, church rectors, board members of local associations).
- Another example of local engagement is the Good Neighbour Program, which is a common sense approach to assist in addressing concerns that are important to landowners and other stakeholders. In this framework Talisman attempts to limit environmental impacts; noise, light and traffic resulting from our operations; hold contractors accountable; investigate, act and resolve concern; and implement a Local Economic Engagement Strategy.

Nikolaas Baeckelmans (ExxonMobil) gave a presentation on good practices in the area of social and community engagement. The presentation can be found here.

The main point of the presentation and the ensuing discussion were as follows:

- One key message is that in Germany fracturing technology has been executed more than 300 times and yet no environmental incident has occurred. It was noted that operations in the area of Munsterland generated negative public perceptions because of the lack of past exploration and production in the area (as opposed to lower Saxony which has a historical experience with such activity, i.e. 16,130 wells drilled over several decades). Broadly, up until the controversial 'Gasland' documentary, the public had by and large accepted oil and gas exploration activity onshore in Germany.
- Since 2011 negative public perceptions towards shale gas and fracturing activities have spilled over into conventional gas and oil production. ExxonMobil's response was to create a framework for information and dialogue which included early, open and proactive information sharing with citizens (as

well as, inter alia, talks with mayors, round tables with authorities, press/politics/public engagement, info-mobiles and advertising campaigns, internet presence, etc.)

- ExxonMobil also undertook a rigorous, scientific study of the effects of shale gas exploration using a neutral body of scientific experts. The current focus is to build multiple show-cases at early exploration stage to demonstrate safe and prudent operations. ExxonMobil invited the JRC and other stakeholders to participate in the pilot project to test for aspects such as groundwater, seismicity, fracture-geometry, etc.

Malcolm Rice-Jones (International Association of Oil and Gas Producers, OGP) gave a presentation on the industry's response to the disclosure of hydraulic fracturing fluids. The abstract can be found here and the presentation here.

The main point of the presentation and ensuing discussion were as follows:

- OGP has been facilitating the voluntary disclosure of chemicals used in hydraulic fracturing of European shale gas wells. The presentation gave an overview of the shale gas extraction process and the safeguards built into it. The Hydraulic Fracturing Fluid and Additive Component Transparency Service (FACTS) programme is a step in the direction of providing industry transparency. Progress on developing this web based tool to date as well as expected activity over the next few months were discussed along with potential future developments.
- FracFocus is a key initiative to disclose chemicals used in hydraulic fracturing in the United States. The aim is to ensure maximum disclosure consistent with protecting proprietary information sufficiently to encourage innovation.
- FracFocus will be extended to Europe and will provide per-well information that will include, inter alia, data on the operator, location of well, depth, volume of water used and chemical usage (% by mass). A European focused variation of version 2.0 will due for release in late 2013

10 Summary of session 7: JOINT INITIATIVES AND EUROPEAN PLATFORM & WORKSHOP CONCLUSIONS

The final session started with **Anton ANTONENKO**, DiXi Group, presenting "A Ukrainian platform for shale gas: Kyiv Unconventional Gas Institute". His presentation provided information on the expected unconventional gas reserves in Ukraine and discussed the development of these resources. It also addressed main public and political concerns voiced in Ukraine. The presentation gave information about the concept of the Kyiv Unconventional Gas Institute and presented the online platform developed to promote the dialog between stakeholders.

The remainder of session 7 was devoted to a discussion on a "European Platform on Shale Gas" , jointly chaired by **Arne Eriksson**, JRC, and **Michael Schütz**, DG ENER.

Arne Eriksson started the discussion by presenting a proposal on how to organize such cooperation, and questions to address, based on a draft text developed jointly by JRC and DG ENER (circulated to the workshop participants ahead of the meeting). Arne Eriksson stressed that these ideas were just simply to start the discussion and should be further developed and agreed among participants.

The background for this discussion was the European Parliament report on unconventional hydrocarbons, drafted by MEP Tzavela and adopted on 21 November 2012, highlighted the importance of creating "*… independent platforms composed of industry and science representatives aiming to provide opinions and establish good practices…*".

The ideas presented for discussion were circulated prior to the meeting as reported in the text box in the following page. The discussion that ensued is summarized below.

1. **Øystein Lind** asked rhetorically – should we create such a platform or not? He offered conditional support. There are already many initiatives – OGP, Shale Gas Europe (platform for media outreach by companies), - we need to find a place for this platform within all the others. The proposed platform can bring together research and academic institutions.
2. **Rachel Bonfante** argued that we need a good balance of stakeholder participants. There will be overlap, so we should look at what has come before and identify the missing elements. Good practices are already underway by OGP, and have already been issued by other industry players (including DNV, UKOOG and others) so we should be careful not to waste time and to create wasteful repetitions. Pilot projects and demonstration projects with involvement of independent research institutions are extremely important. On the issue of baseline monitoring and independent verification, she mentioned that the offshore safety directive has very clear provisions and suggested that the EU should use this same approach.
    - Arne Eriksson asked what would be good balance of stakeholders. Rachel Bonfante answered that everyone in the chain should be represented.

The main goal would be to contribute to the safe and efficient shale gas development by bringing together industry and research representatives, sharing information, reviewing R&D results and needs as well as communicating with policy makers.

The platform should operate by:

- Bringing together stakeholders in a structured dialogue to achieve information and knowledge sharing;
- Presenting and discussing European Research agendas/projects and results as well by identifying gaps and R&D needs;
- Sharing information on exploration and demonstration projects;
- Establishing state of the art knowledge and best practices; and
- Communicating with policymakers.

The platform could address some of the following questions:

- What developments are undertaken, or should be undertaken in Europe to pave the way for shale gas E&P in Europe?
- What are the obstacles (technical, social, economic, legal…) for such a development?
- What are the results of on-going and planned exploration and demonstration projects (resource potential, environmental impacts, indications for best practices…)?
- What technologies (technical equipment, processes/procedures, communication methods, etc.) are available and which may be considered "best technology", offering advantages in terms of lower environmental risk, lower impact/intrusion locally (land, traffic, air, visual…) as well as efficiency/lower production costs?

Additional issues could include various social and (macro) economic aspects: expected benefits such as investments, job creation, supply of goods and services, taxes, royalties, induced effects, environmental and climate, etc. Also, the platform should address specific questions raised by various policy makers (governments, EU institutions, etc.).

Possible ideas for a Platform or Network, developed by JRC and DG ENER and circulated to the workshop participants ahead of the meeting

3. **Nick Riley** reminded that there is a European Energy Research Alliance (EERA) that aims at having joint programmes between member states by getting together - with help from the Commission - national research institutes. Perhaps this is closer to the technology platforms? They look at knowledge gaps, make roadmaps, etc. So where can we position ourselves? It would be nice to have a balanced group of stakeholders giving a trusted source of information.
    - Arne Eriksson suggested that the platform, in addition to the EERA group, could not only be about research and data collection, but could also have a role about communicating with policy-makers.
    - Michael Schütz remarked that the technology platforms are linked to SET plan that have specific R&D needs for new technology (e.g. CCS, PV, etc.). Shale gas technology has much more maturity – it's about environmental impacts, etc. There is no intention to include shale gas in SET plan, so there's not much risk of overlap there.
4. **Ruud Weijermars** suggested that rather than doing inventorying we should ask what can we do to add new insights. He stated to be a critic of inventorying and not taking action. This should be ambitious and pro-active platform, more so than the

existing initiatives. He stated that we should make sure our energy is spent in the most effective and efficient way. How do we make that happen?

5. **Anton Antonenko** suggested that the platform under discussion could be the umbrella organization for national platform and initiatives. It could be useful to share results from other platforms, and to ensure exchange of expert opinions.

6. **Brian Horsfield** concurred with Ruud Weijermars, and suggested we get involved in all European drilling activities for shale gas. The operators will already be working with the groups they prefer as regards shale characterisation. He made the following two points:

   - Examining the sediments in the grey zone lying between the shallow and deep foci of interest is key for mapping petrophysical properties, and modelling leakage scenarios, and thence building a monitoring database for Europe. Existing geological survey data forms a backcloth for interpretation.
   - Monitoring. International teams can be built and deployed as fracking sites become available. Every opportunity that presents itself should not be wasted. Getting some EU funds moving is the logical step to coordinate the issue of safety. The EU Energy and EU Environmental groups should unite on this issue, irrespective of whether you are for or against. Testing is needed, and money for honest brokers to do the testing is a prerequisite.

7. **Nikolas Baekelmans** suggested we need to get data from pilot projects before a regulatory framework is in place, including multi-well projects, e.g. in Germany. This could be part of a JRC exercise. He also suggested that we should not talk about "best practices" but "good practices" because these practices are not necessarily universally applicable. Another idea is to know the process of how public institution reports are produced and disseminated. JRC could also play a bridge-building role between US and Europe (by working with EPA, DoE, etc.) and hoped that future events will bring in more US expertise. Finally, he stressed the need for more research on competitiveness (e.g. domestic versus non-domestic production).

   - Arne Eriksson mentioned, to the last point, that JRC is planning a follow up study (from energy market impacts) on wider economic impacts from shale gas.

8. **Marie-Valentine** Florin raised 5 fundamental questions regarding a platform:

   i) Who will organize this? She would like to see it as a consortium with different chapters.

   ii) Where would it be located? It should be a neutral and independent place.

   iii) What would its objective be? Responsible and sustainable shale gas for the benefits it can bring to social and economic development.

   iv) What could it do? Organise collection and sharing of data. Share experiences on-good and bad practices. Communication. Organisation of capacity building and knowledge transfer on technical, regulatory and policy issues between countries. Training course on e.g. risk communication and community involvement. Developments of standards.

v) Who should participate? Industry, science, civil society, and public sector (governments, authorities, IOs), i.e. at least 4 chapters. And it should probably be international, i.e. including e.g. USA, India, China, S. Africa, etc.

9. **Andrei Bala** stated that the purpose of the workshop is focused on how safe is shale gas exploration and production in Europe. If this will be established, then the relations between the different type of stakeholders will be much easier and it will allow decision-makers in each EU country to make informed decisions. Since the regions in EU are very different with respect to local geology, pilot studies should be carried out in each country (for each geologic region) and should at least address: (1) geological and petrophysical properties of the rock layers between the surface and the productive shales; (2) geophysical characterization and presence of deep fractures or faults; (3) local seismic hazards (by monitoring the area with portable seismic stations for possible induced earthquakes during the drilling, fracking and extraction of shale gas). The environmental impact assessment carried out in Poland at the Łebień well (presentation by M. Konieczynska) is a very good example of such a pilot study and it should be continued for at least one year of production. In general, pilot studies should be done by independent parties and should be financed either by country scientific authorities (not possible in all countries) or by EU Framework Programme Horizon 2020. Their outcome should be included in a common European database. The calls for proposals of pilot research projects should involve several institutes, representing multiple disciplinary fields and specifically geology, tectonics and the monitoring of induced seismicity.

10. **Steve Garrett** stressed first the importance of data; as a practical step, it would be useful to have shared European view of data standards, baseline measurements, surveillance data, with clear bare minimum requirements. Second, he said that a better understanding of the first principles of rock properties and reservoir performance is needed, building on work already being done at universities e.g. in Leeds. Third, risk assessment and risk management methodology had emerged at the workshop as key topics needing further work at the EU level; identification of high risks would help target more research. Fourth, there was an opportunity for a 'platform' to discuss risk communication and community engagement e.g. the diversity of community engagement needs and experiences. Fifth, a pilot development project (as proposed by ExxonMobil in Germany) – would provide subsurface and operational data from controlled experiments- JRC should look into this very seriously.

11. **Iuliana Chidu**, representative of the Romanian environmental authorities, brought up (1) the necessity of presenting a report on the use of water, energy and chemicals, (2) a comparative analysis of the carbon footprint per energy unit from unconventional sources compared to energy from conventional sources, as well as (3) the possible medium and long term impact on agriculture. A clarification was also requested regarding the possibility of including energy from unconventional sources and its ratio in the energy mix at EU level for 2020.

12. **Lars Sörum** supported the building of a European databases and supported OGPs view on independent verification. He expressed his belief in the importance of the following peer reviewed research topics: understanding rocks; understanding gas migration; understanding how chemicals behave over time in that environment,

and fugitive methane. A platform should feed into policy-making and be a trusted source of information, objective, fact-based research. In terms of hosting, he stated his belief that JRC is best placed to coordinate.

13. Other ideas mentioned during the discussion included:

    - the activity should addressed policy-makers,
    - inventory of reported accidents worldwide,
    - a platform should also include civil society,
    - the environmental impact assessment carried out in Poland at the Łebień well (see presentation by M. Konieczynska) was a good example, and should be of interest in the Horizon 2020, (the upcoming EU Framework Programme for Research and Innovation),
    - safety/environmental issues of shale gas – water contamination.

14. **Didier Bonijoly** and others mentioned the initiative from EERA, who have started to think about which type of research can be done on shale gas. This platform should be supported by JRC, but as a place where everybody shares information.

15. **Michael Schütz** said we do not know if Horizon 2020 will include research on shale gas. The EU research budget is not as large as e.g. funding provided by the US federal government. Therefore, member states and industry might be more likely source for funding. He added that the energy Commissioner, Günther Oettinger, thinks shale gas is important for competitiveness and security of supply. The Commissioner is keen to see the industry develop if it can be done without harming the environment.

16. **Nick Riley** said that there needs to a trusted source with a broad spectrum of knowledge in Europe that provides information to the policy-makers and citizens. If it's not, it will be a shame.

17. **Jan Hupka** said we need a shale gas development platform. He stated that the basics are already outlined in the draft proposal, and proposed to move to the next step, i.e. establishing a working group to work out the details.

18. **Ruud Weijermars** suggested that we might be underestimating the sense of urgency given the demand for energy outside Europe, and we could have a real energy security on our hands. Arne Eriksson stated, regarding the next step, that JRC is willing to take the lead to develop these ideas further. This should be not just a JRC project, but a network or platform with close involvement of its members.

19. **Namık Yalçın** stated that the suggested R&D platform cannot (and should not) conduct R&D studies regarding the entire spectrum of the shale gas process in Europe. What it may (or should) do is to act as a body pointing out and setting priorities in all related aspects of shale gas R&D in Europe. It may also try to bring all relevant information and data together to form a database or center of trusted source of information. However, how such knowledge – gained and created at different locations and institutions in Europe – can/will made be available for this platform would require a wide European agreement.

Michael Schütz and Arne Eriksson closed the meeting by thanking all the speakers and all participants for joining the workshop and contributing to the discussion.

10.1 CONCLUSIONS

The following summarises the above discussion concerning the network or platform.

Support for a Platform:

In general the participants expressed support for the idea of creating a network or a platform on shale gas, along the principles put forward by JRC and DG ENER. It would be important, however, to take into consideration several already existing initiatives to avoid unnecessary overlapping of activities.

Goals and Objectives

The general goal put forward in the draft text was

"To contribute to the safe and efficient shale gas development"

An alternative goal was suggested as

"To promote responsible and sustainable shale gas
for the benefits it can bring to social and economic development"

Some more specific objectives mentioned were:

- Communicate with policy-makers to inform the policy-making process;
- Become a trusted source of information, displaying a broad spectrum of knowledge.

Both general goals and specific objectives will need to be discussed further.

Modus operandi and Location

There needs to be a good balance between participating stakeholders, in order to become a trusted source of information. Invited to this meeting were organisations representing the academia, the industry and national geological surveys, but some participants wondered whether all stakeholders (i.e. civil society, the public sector, etc.) should participate. The question of geographical uptake was also mentioned, with specific suggestions to have a network or platform with a truly international dimension. Specifically, the United States – the country leading the technological development in this area – were mentioned. This will need further discussion.

Several participants suggested a leading role for JRC but other ideas were discussed. Which organisation (or organisations) should lead the effort is a key question to address.

Working areas

During the discussion several topics were proposed for inclusion, included in the non-exhaustive list below. The topics to be addressed by a potential network or platform should strike a balance between pure R&D needs and policy relevance.

- Pilot projects with involvement of international teams of independent research institutes or laboratories to perform baseline measurements, data gathering, monitoring etc.
- Competitiveness and security of supply.
- Geological strata and source rock characteristics, seismicity.
- Collection and sharing of data, good practices, standards on data formats, baselines etc.
- Communication, risk communication, capacity building, community engagement.
- Risk assessment, risk management and risk governance.
- Safety and environmental aspects (chemicals, methane migration into water, other potential water contamination risks, accident and incident reporting).

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11 Abstracts and Presentations

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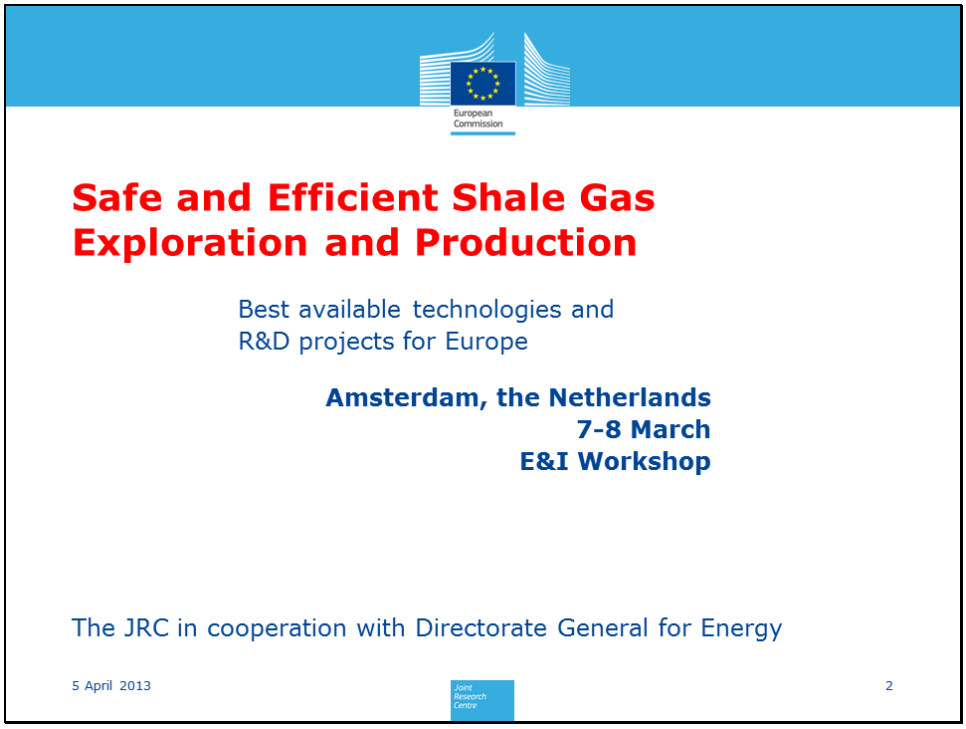
11.1 Welcome and opening of the workshop

Marcelo MASERA, Head of ES Unit, JRC IET

11.1.1 Presentation



Welcome to….

41 participants
From > 20 countries
Representing

- Industry
- Academia
- Geological Surveys
- EC

Marcelo Masera
Head of Unit
Energy Security Unit

DG Joint Research Centre

The European Commission's in-house science service

Who are we and what do we do?

JRC is the European Commission's in-house science service. It provides the science for policy decisions, with a view to ensuring that the EU achieves its Europe 2020 goals for a productive economy as well as a safe, secure and sustainable future.

The JRC plays a key role in the European Research Area and reinforces its multi-disciplinarity by networking extensively with leading scientific organisations in the Member States, Associated Countries and worldwide.

Our Mission… is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies.

Our Vision driven by the Europe 2020 Strategy… is to be a trusted provider of science-based policy options to EU policy-makers to address key challenges facing our society, underpinned by internationally-recognised research.

Our Impacts for the EU citizen… supporting general well-being via harmonised research on energy, environment, transport, climate change, safety of food and consumer products, crisis management, and nuclear safety and security, that have important positive impacts on the daily life of the citizen.

The JRC inside the European Commission

President
José Manuel Barroso

27 Commission Members

Commissioner
Mairé Geoghegan-Quinn
Research, Innovation & Science

Director-General
Dominique Ristori
Joint Research Centre

DG Research & Innovation (RTD)

Panorama of the European Union

European Court of Auditors | European Parliament | The Council of the European Union | The Committee of the Regions

Court of Justice | European Commission (27 Commission members) | Economic and Social Committee

Commissioner | Commissioner | Commissioner | Máire Geoghegan-Quinn | Commissioner

SG | RELEX | ENTR | MOVE | ENER | RTD | JRC | CLIMA

IRMM | IES | IPSC | IPTS | IET | IHCP | ITU

Science-based input to EU legislation and standardisation

JRC

Scientific-based Support

EU Legislation Standardisation

Innovation Jobs & Growth

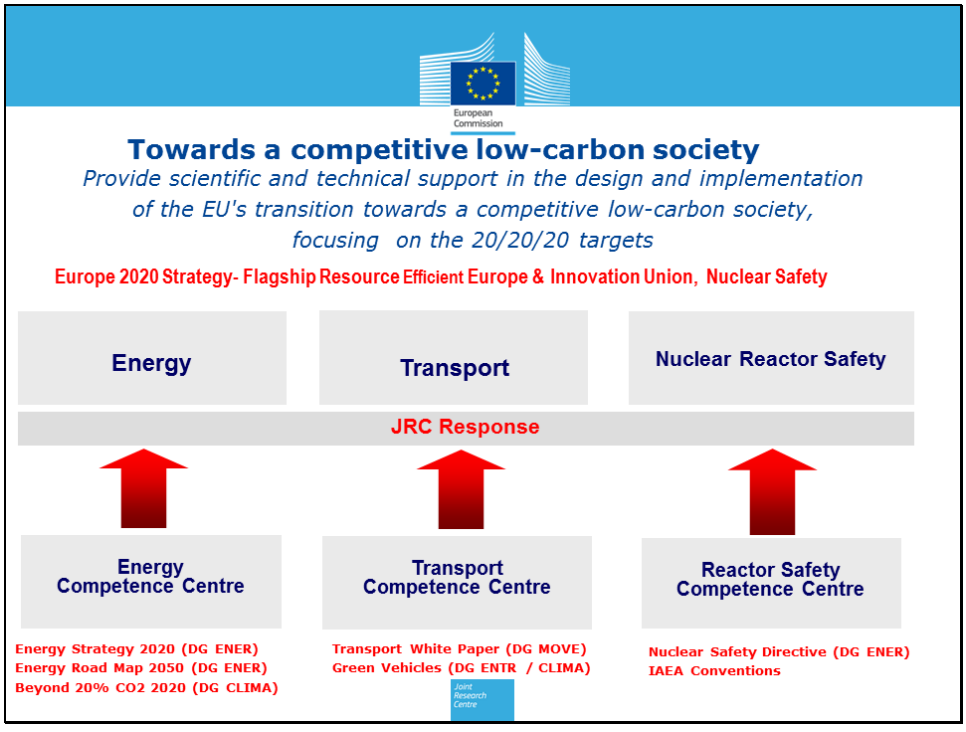
5 April 2013

9

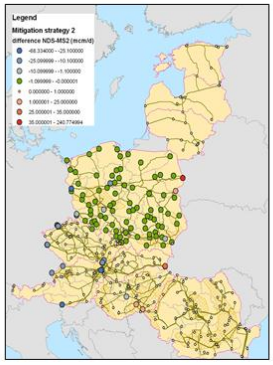
DG Joint Research Centre
Institute for Energy and Transport (IET)

(Overview)


European Commission
Institute for Energy and Transport
Ispra, Italy
Petten, The Netherlands
The mission of the Joint Research Centre – Institute for Energy and Transport (IET) is to provide support to Community policies and technology innovation related both:
• energy - to ensure sustainable, safe, secure and efficient energy production, distribution and use and
• transport -to foster sustainable and efficient mobility in Europe.
Joint Research Centre

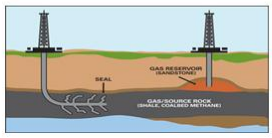

European Commission
Towards a competitive low-carbon society
Provide scientific and technical support in the design and implementation of the EU's transition towards a competitive low-carbon society, focusing on the 20/20/20 targets
Europe 2020 Strategy- Flagship Resource Efficient Europe & Innovation Union, Nuclear Safety
Energy
Transport
Nuclear Reactor Safety
JRC Response
Energy Competence Centre
Transport Competence Centre
Reactor Safety Competence Centre
Energy Strategy 2020 (DG ENER)
Energy Road Map 2050 (DG ENER)
Beyond 20% CO2 2020 (DG CLIMA)
Transport White Paper (DG MOVE)
Green Vehicles (DG ENTR / CLIMA)
Nuclear Safety Directive (DG ENER)
IAEA Conventions
Joint Research Centre

Security of energy supply – Gas & Oil



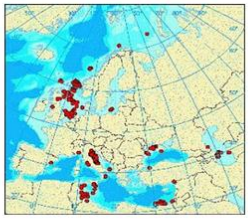
Gas Networks & Disruption scenarios

(Regulation 994/2010)



Unconventional gas sources: techno-economic study (Sept 2012)

(DG ENER initiative)



Offshore safety

(COM/2011/688)

Joint Research Centre

Security of energy supply – Super Grids

JRC contribution:

Communication on smart grids (202/2011)

Standards (Mandate 490)

European Industrial Initiative on Electricity Grids (SETIS)

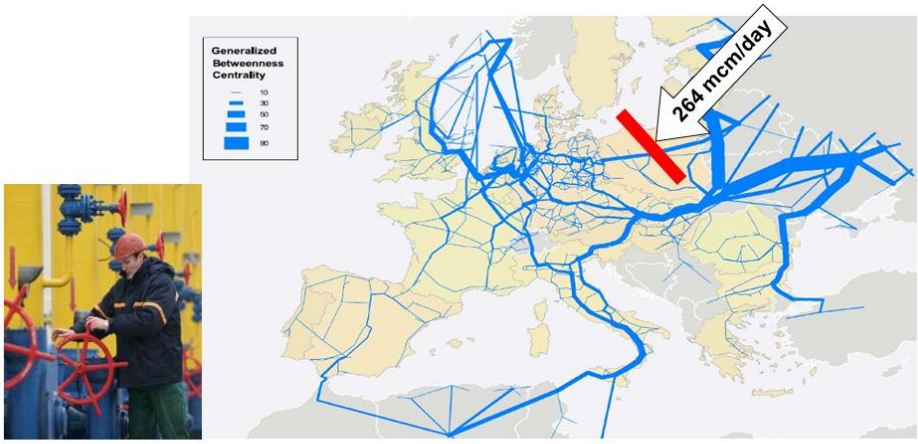
Smart Grids Task Force (DG ENER)

Industry:

- MEDGRID
- Eurelectric
- ENTSOE

Joint Research Centre

Gas Supplies to Europe



80 % of Russian gas passes through Ukraine

Shale Gas at JRC

Institute for Energy and Transport
- **Report: Unconventional Gas: Potential Energy Market Impacts in the EU**
- **Ongoing: Best available technology; Wider economic implications of domestic shale gas**

Institute for Environment and Sustainability
- **Ongoing: Study focused on land use and water demand**
- **Draft report: Literature review report on environmental and social impacts**

Institute for Prospective Technological Studies
- **Review of Best Available Technologies reports (BREFs, Mining Waster Directive)**

Institute for Health and Consumer Protection
- **Review of REACH registration dossiers for fracturing fluid additives**

5 April 2013 16

Today's Workshop:

Technical Sessions → **Today's Conclusions**

Platform → **Tomorrow's Cooperation**

Forward Looking

- Working Together
- Prioritization, Data, Methods
- Dialogue among Stakeholders

Bridging The Gaps

What do authorities, industry and citizens ask for?

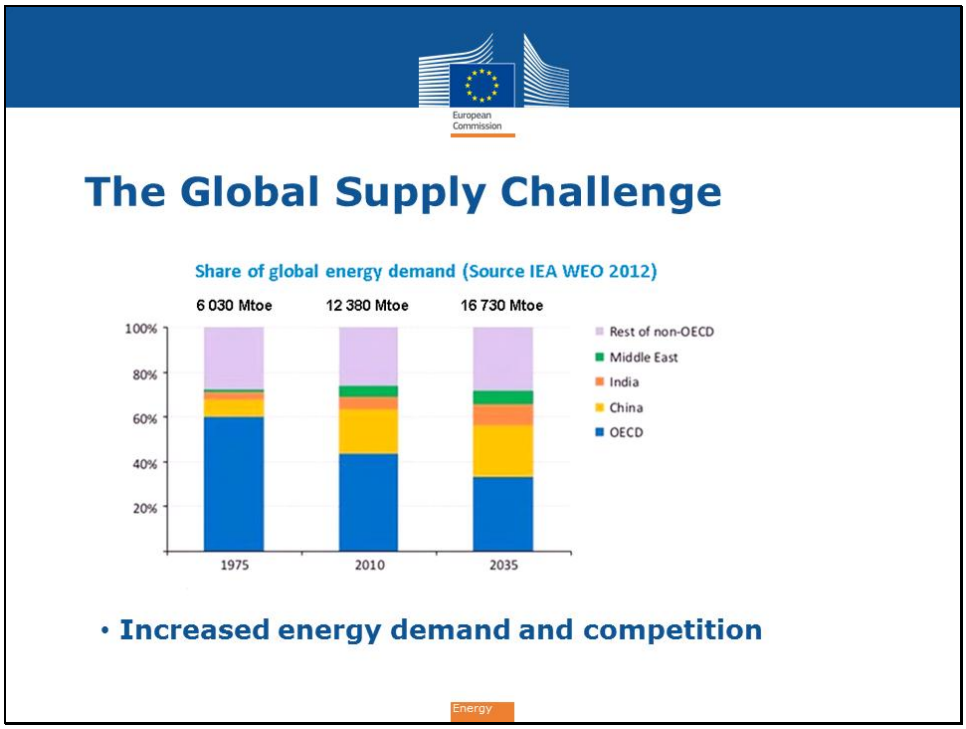
(risk & reward)


European Commission
Joint Research Centre (JRC)
www.jrc.ec.europa.eu
Contact: jrc-info@ec.europa.eu
Supporting legislation
Serving society
www.jrc.ec.europa.eu
Robust science for policy making
JRC
EUROPEAN COMMISSION
Serving society
Stimulating innovation
Supporting legislation
5 April 2013
Joint Research Centre
19

11.2 Opening remarks by DG Energy

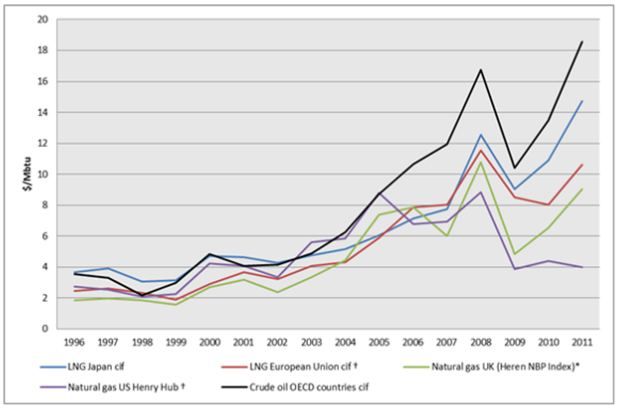
Michael SCHUETZ, DG Energy

11.2.1 Presentation



Competitiveness Challenge

Global natural gas prices

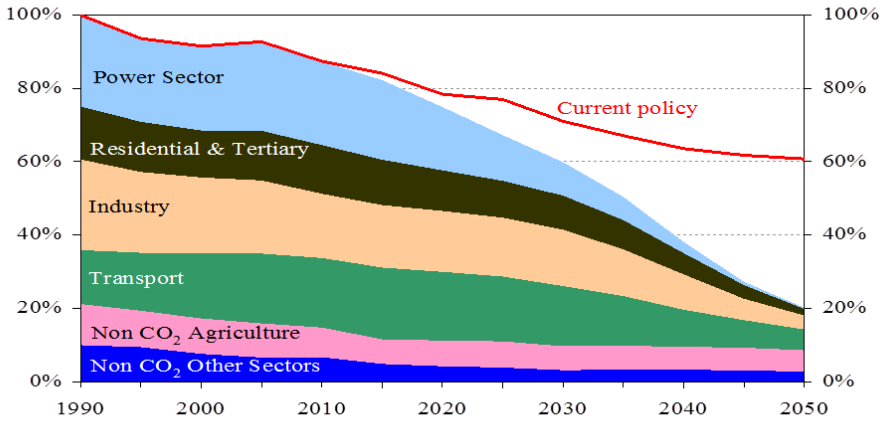


Source: BP, 2012: Statistical review of world energy. Note: cif=cost+insurance+freight (average prices).

- **Affordability for citizens**
- **Renaissance for US manu-facturing**
- **Impact on competitive-ness of European industry**

Energy

Decarbonisation Challenge



Energy

The Role of Natural Gas

Less CO_2 intensive fuel

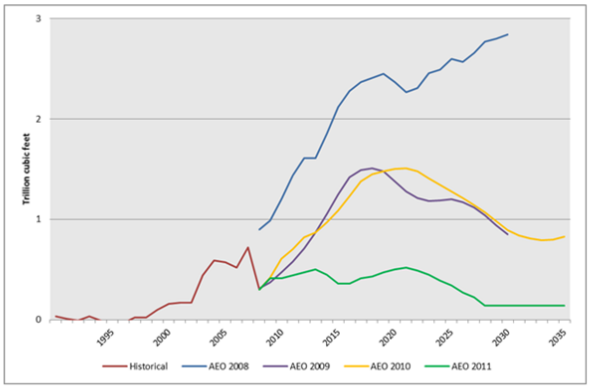
Gas-fired power stations support the integration of renewables

Diversity of sources
(pipeline, LNG, indigenous production, gas-to-power)

Energy

Impact of US 'Shale Revolution'

Historical and projected net US LNG imports

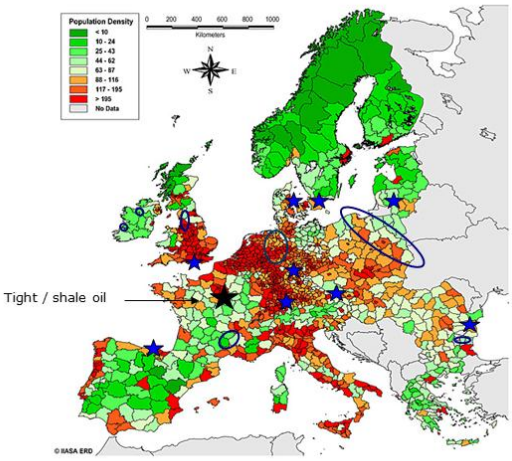


US Energy Information Administration, 'Various American Energy Outlooks'

- **US now world's largest gas producer and only uses 10% of its LNG import capacity**
- **More LNG available for Europe → Pressure on prices**

Energy

Shale Gas in Europe ?



Commission Work Programme 2013:

"Environmental, climate and energy assessment framework to enable safe and secure unconventional hydrocarbon extraction"

Energy

Conclusions

- **Unconventional gas in Europe?**
  - **Geology, market, public acceptance…**
- **Needed for public acceptance**
  - **Improved technologies and practices**
  - **Adequate regulatory framework**
  - **Citizens: benefits, information and consultation**
- **Until 23 March 2013: Public Consultation**

  http://ec.europa.eu/environment/consultations/uff_en.htm

8

Energy

11.3 Workshop agenda, objectives and expected output

Arne ERIKSSON, JRC IET

11.3.1 Presentation

Welcome to….

41 participants, > 20 countries

Representing

- **Industry**
- **Academia**
- **Geological Surveys**
- **EC**

But, why are we here?

DG ENER/JRC study

Published *September 2012*

Why? *Contentious subject with policy implications*

Aims

- *Assessment of the evidence on the impact on energy markets.*

Contents

- *Review of regional and global estimates*
- *Review of technologies*
- *Land and market access*
- *Impact on the European and the global energy systems*

Methodology

- *Evidence based policy and practice*
- *Energy Modelling*

4

Agenda

- *7 sessions of 2 to 3 presentations chaired by JRC*
  - followed by 20-25 minutes of discussion
- *Discussions: What conclusions can we reach?*
- *Speakers: 20 min inc. Qs (aim at 15-17 min)*

5

Objectives

- *To present and discuss ongoing European research, development and demonstration projects*
- *To explore the interest in, and viability of a European Platform for Shale Gas Development*

6

Expected output?

- *Summary and Conclusions – to be circulated for comments*
- *Workshop report/proceedings – public document:*
  - Agenda, participants list
  - Summary and Conclusions
  - Abstracts & Presentations (Voluntary. Only upon written agreement from each speaker)
- *Discussion on the need/viability of a Platform?*

7

11.4 Chevron's shale gas research and development: key themes, key questions and key partnerships

Steve GARRETT, Chevron

11.4.1 Abstract

Chevron is currently pursuing shale hydrocarbon exploration and development opportunities in several countries. Working in partnership with regional business units, the Energy Technology Company (ETC) provides technical services and technology development to meet business challenges.

A new cross-functional Shale Unit has been formed within ETC. This is organized around four key technical themes:

1. Core area identification
2. Well stimulation
3. Footprint minimization
4. Water management

Some key challenges which are particularly relevant to Europe include:

- Finding core areas for development with minimal well and seismic data
- Understanding mechanisms of gas flow through rock and fractures
- Minimizing the surface footprint of operations by maximizing the number of wells per pad
- Minimizing water usage and maximizing water recycling

This work is benefitting from existing skills and competencies in the company. Chevron also values partnership with universities and commercial groups.

Independent, peer-reviewed science, accompanied by appropriate press releases and articles, is critical to inform public debate and policy making, as shown during 2012 consultation in the United Kingdom.

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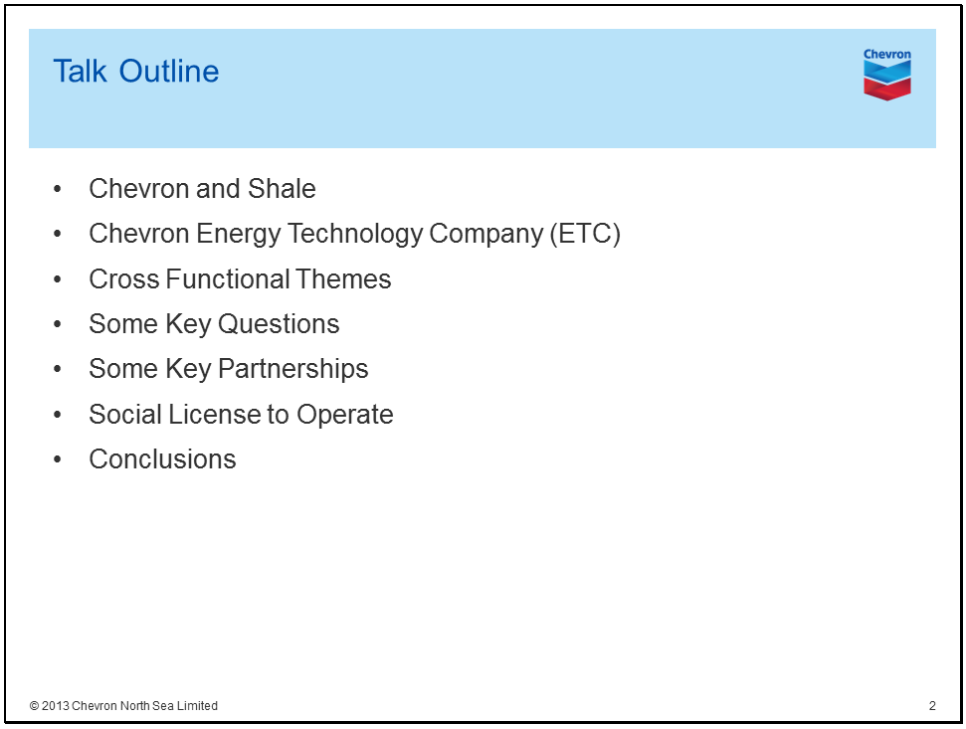
11.4.2 Presentation

Chevron's shale gas research and development: themes, questions and partnerships

Chevron

Steve Garrett
Manager, Global Technology Centre
Chevron Energy Technology Company
Aberdeen

Presentation at JRC Workshop
Amsterdam, March 7-8, 2013
Organized by European Commission Joint Research Center



Talk Outline

Chevron

- Chevron and Shale
- Chevron Energy Technology Company (ETC)
- Cross Functional Themes
- Some Key Questions
- Some Key Partnerships
- Social License to Operate
- Conclusions

 2

Chevron 2012 Shale Activity

Chevron Shale Activity Onshore Europe

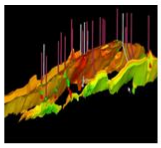
Exploring more than
1.3 million hectares
under recent and pending
agreements with the
governments of:

- Bulgaria
- Lithuania
- Poland
- Romania
- Ukraine

Chevron Energy Technology Company (ETC)

- Integrated upstream/ downstream
- Serves Chevron worldwide
- Expert technical consulting
- R&D for new technology solutions
- > 2,600 employees, mostly in US
- ~100 employees in UK

ETC Functional Departments



Reservoir & Production Engineering

Earth Sciences

Facilities Engineering

Process, Analytical & Catalysis

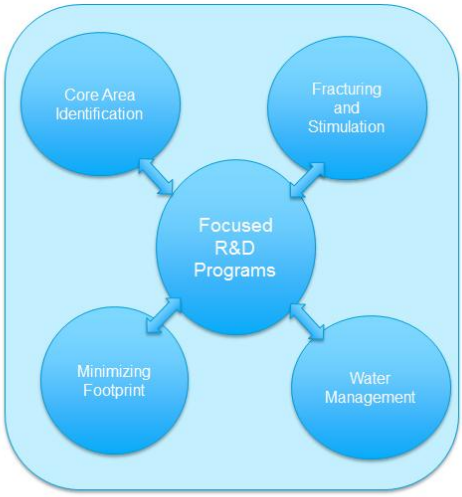
Drilling & Completions

Technical Computing

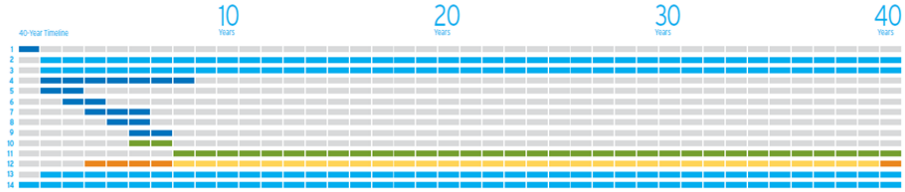
Upstream Workflow Transformation

Health, Environment & Safety

ETC Shale Unit
Cross-Functional Themes



Developing Natural Gas Resources in Europe
It Takes Time



1. **Bids and Licenses** *(Months to years)*
2. **Permitting** *(Full lifespan of the project)*
3. **Impact Assessment** *(Full lifespan of the project)*
4. **Data Analysis** *(6-7 years)*
5. **Seismic Surveys** *(1-2 years)*
6. **Exploration Drilling** *(2 years)*
7. **Appraisal/Pilot Testing** *(2-3 years)*
8. **Commercial Agreements** *(2 years)*
9. **Development** *(1-2 years)*
10. **Infrastructure** *(1-2 years)*
11. **Production** *(30+ year life of recoverable gas resources)*
12. **Reclamation** *(Final months of each exploration/production well and up to a year beyond)*
13. **Contracting for Services** *(Once step 1 is completed, the lifespan of the project)*
14. **Government and Community Engagement** *(Full lifespan of the project)*

} **Ongoing Activities**

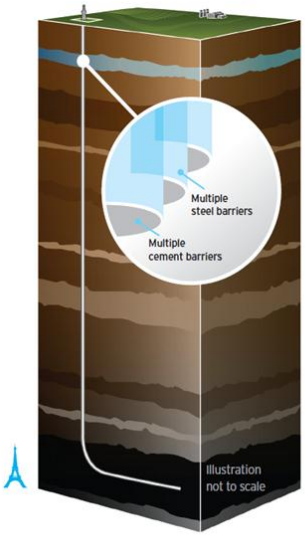
} **Exploration – up to 8 years**

} **Production – life of field approx 30 years**

} **Reclamation – ongoing**

Core Area Identification

Stimulation and Well Design



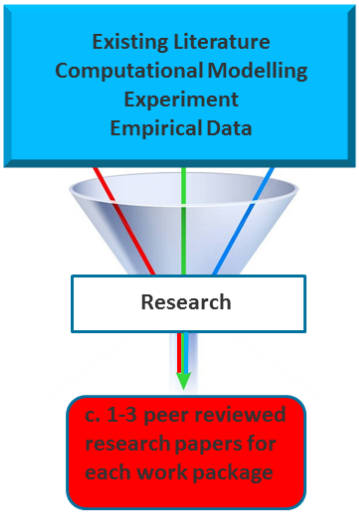
Water Management

Minimising Footprint

R&D Partnership

R&D Partnership
ReFINE proposal

- WP1 – Induced Seismicity
- WP2 – Fugitive Emissions
- WP3 – Subsidence
- WP4 – Long Term Impact of Fracking Fluid
- WP5 – Hydraulic Fracture Height
- WP6 – Reservoir Behaviour After Abandonment
- WP7 – Water – Sourcing, Disposal and Clean-up
- WP8 – Wellbore damage and Integrity



The Chevron Way

Vision

At the heart of The Chevron Way is our vision ... to be the global energy company most admired for its people, partnership and performance.

Our vision means we:

- safely provide energy products vital to sustainable economic progress and human development throughout the world;
- are people and an organization with superior capabilities and commitment;
- are the partner of choice;
- earn the admiration of all our stakeholders – investors, customers, host governments, local communities and our employees – not only for the goals we achieve but how we achieve them;
- deliver world-class performance.

Values

Our company's foundation is built on our values, which distinguish us and guide our actions.

We conduct our business in a socially responsible and ethical manner. We respect the law, support universal human rights, protect the environment and benefit the communities where we work.

Integrity
We are honest with others and ourselves. We meet the highest ethical standards in all business dealings. We do what we say we will do. We accept responsibility and hold ourselves accountable for our work and our actions.

Protecting People and the Environment
We place the highest priority on the health and safety of our workforce and protection of our assets and the environment. We aim to be admired for world-class performance through disciplined application of our Operational Excellence Management System.

Trust
We trust, respect and support each other, and we strive to earn the trust of our colleagues and partners.

High Performance
We are committed to excellence in everything we do, and we strive to continually improve. We are passionate about achieving results that exceed expectations – our own and those of others. We drive for results with energy and a sense of urgency.

Diversity
We learn from and respect the cultures in which we work. We value and demonstrate respect for the uniqueness of individuals and the varied perspectives and talents they provide. We have an inclusive work environment and actively embrace a diversity of people, ideas, talents and experiences.

Ingenuity
We seek new opportunities and out-of-the-ordinary solutions. We use our creativity to find unexpected and practical ways to solve problems. Our experience, technology and perseverance enable us to overcome challenges and deliver value.

Partnership
We have an unwavering commitment to being a good partner focused on building productive, collaborative, trusting and beneficial relationships with governments, other companies, our customers, our communities and each other.

...es

...n, aligns our organization, and differentiates us from the ...ns to successfully manage risk and deliver shareholder value.

People
Invest in people to strengthen organizational capability and develop a talented global workforce that gets results the right way

Execution
Execute with excellence through rigorous application of our operational excellence and capital stewardship systems and disciplined cost management

Growth
Grow profitably by using our competitive advantages to maximize value from existing assets and capture new opportunities

For more information:
The Chevron Way
https://inside.chevron.com/thechevronway/

Major Business Strategies

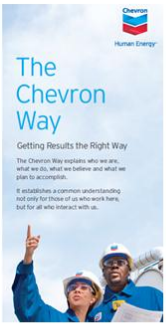
Upstream
Grow profitably in core areas and build new legacy positions

Gas and Midstream
Commercialize our equity gas resource base while growing a high-impact global gas business

Downstream and Chemicals
Improve returns and grow earnings across the value chain

Technology
Differentiate performance through technology

Renewable Energy and Energy Efficiency
Invest in profitable renewable energy and energy efficiency solutions



11.5 Current situation of shale gas exploration in Spain

Jorge LOREDO, University of Oviedo

11.5.1 Abstract

The current situation of the panorama on shale gas exploration in Spain will be presented in this talk. According to their geological typology, there are different basins with possibilities to have important reserves on unconventional gas and they must be investigated in order to evaluate the resources of shale gas. Currently there are exploratory permits in the Autonomous Communities of Asturias, Cantabria, Castilla-León, País Vasco, Aragón, Cataluña and Castilla-La Mancha, and there are too diligences for exploratory permits in the Autonomous Communities of Valencia and Navarra. Some of the most interesting exploratory permits are Gran Enara in Alava, with previous estimations in the order of 185,000 millions of cubic metres of gas, also Arquetu in Cantabria, and Urraca and Sedano in Castilla-León Community. These and other projects have caught the interest of many multinational companies, and this fact has made that nowadays, the surface of the national territory occupied by exploratory permits in land will be the highest of our recent history, assuring a high exploratory activity on the next years. Most of the companies in charge of these researches have not been able to begin with the exploratory campaign due to the great number of restrictions and allegations from the local and regional administrations and from ecological and local associations organized against the hydraulic fracking. Despite of the support from the Ministry of Industry to fracking, there are some regional governments such as Aragón, La Rioja and Cantabria which reject to carry out any fracking and in consequence the unconventional gas resources exploration in their territories.

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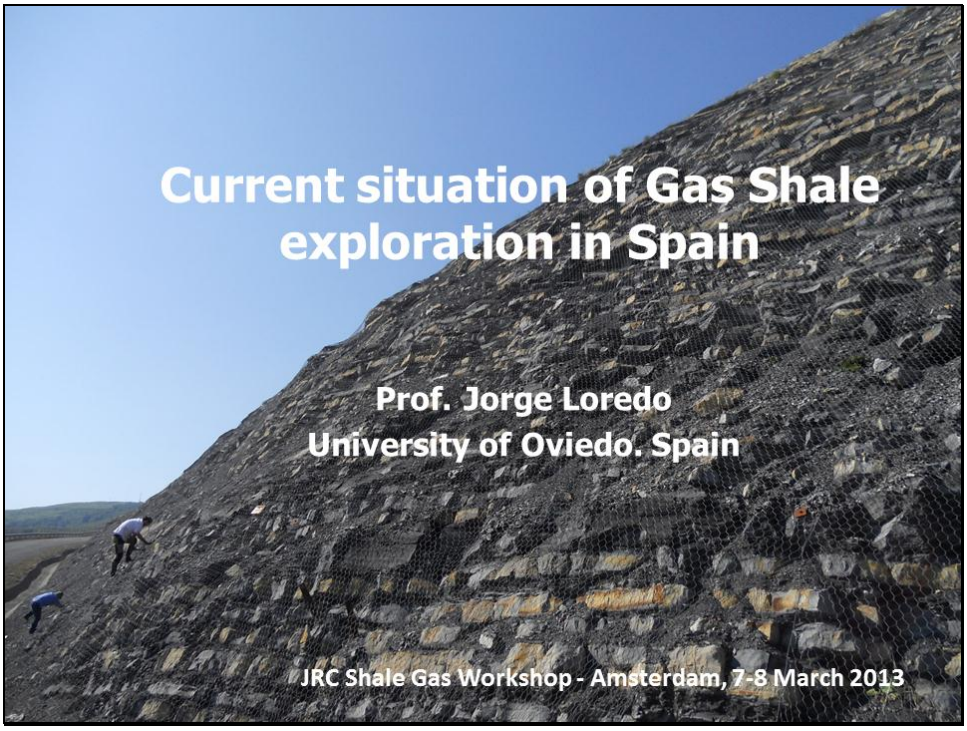
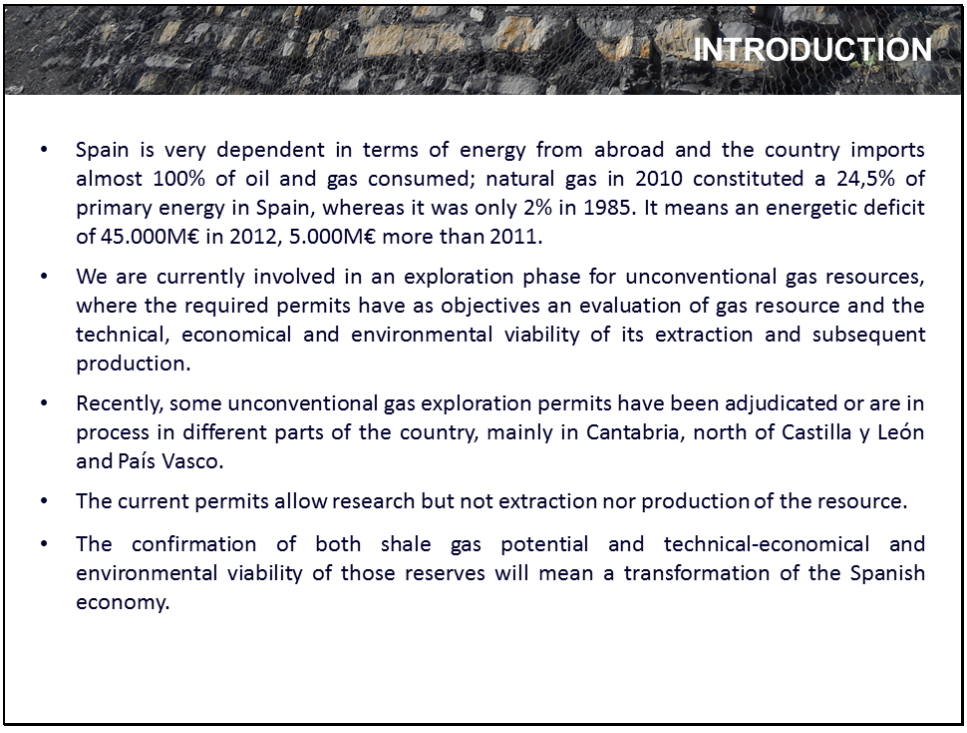
11.5.2 Presentation





RESEARCH EXPLORATORY PERMITS

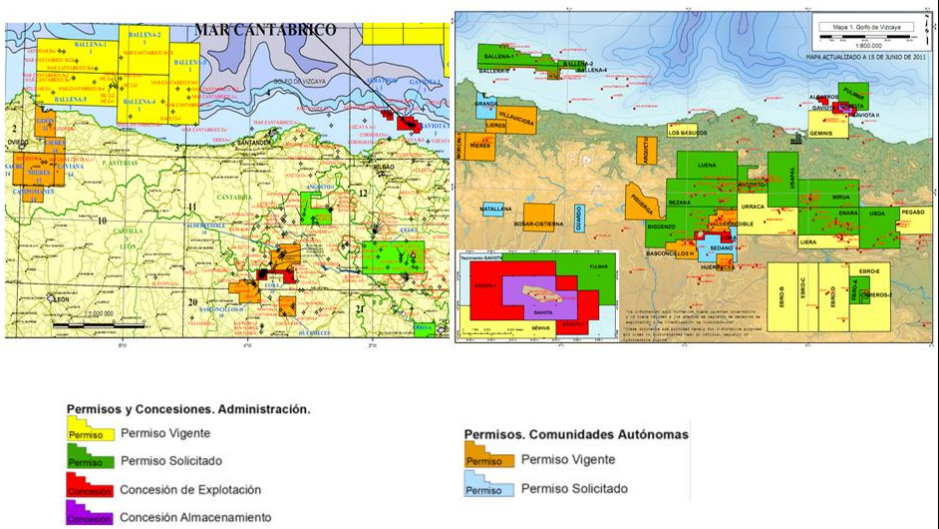
EXPLORATORY PERMITS

- The obtention of exploratory permits, administrative authorisations at a national, regional and local levels, and complex environmental regulations (with fields of action not well defined amongst the different administrations) are restraining exploration activity in Spain of both conventional and unconventional gas resources.
- The outlook for the existence of shale gas is more modest than other countries. The main prospective areas are located in the Vasco-Cantábrica, Pirenaica, Ebro, Guadalquivir and Bética basins.
- The geological age of the potential identified objectives correspond to the Paleogen, Upper and Lower Cretaceous, the Liasic-Jurasic and Westfaliense- Estefaniense (Carboniferous). They are geological formations that have been traditionally studied as potential mother rocks for hydrocarbons.

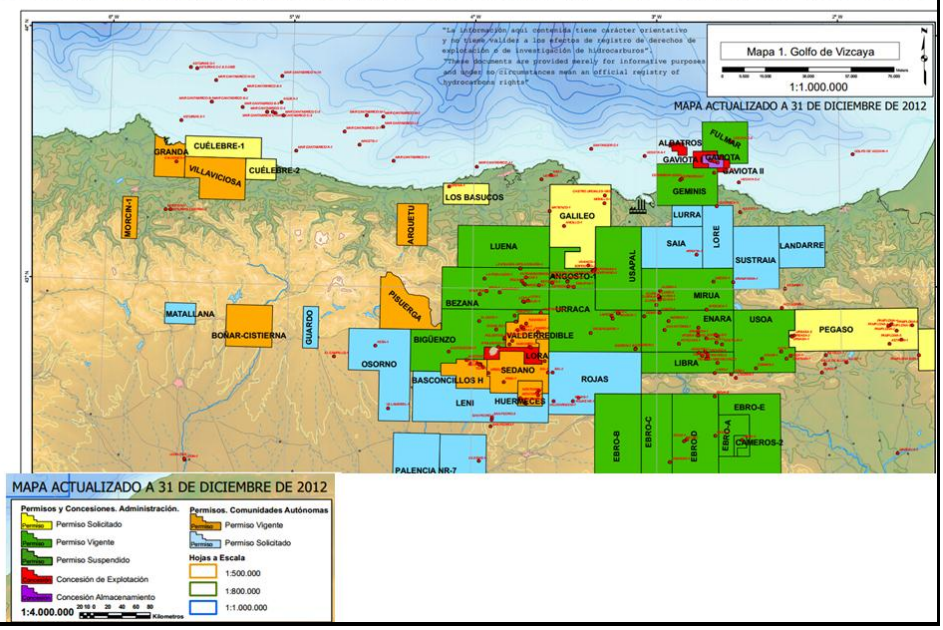
EXPLORATION ACTIVITIES

- Those factors have led to a significative increase of exploration requests in Spain from public and private companies, as shown the 45 applications for exploration permits to the Ministry of Industry in 2011, considering that the annual average was 15 applications per year.
- There are several companies involved in the development of different shale gas projects in the country. The companies are involved in an intense hydrocarbons research and prospecting programme, including office work, seismic data acquisition and exploratory drills in order to value the potential to obtain research permits.
- Despite the interest of the companies, exploratory activity is due to the different problems to obtain the corresponding permits and authorisations. The Cantabrian basin has become an interesting area for the exploration of unconventional gas resources. The following permits have been already obtained: Luena, Arquetu, Urraca, Enara, Miróa, Usapal and Usoa.
- However, there are nowadays different social movements in Spain against the use of fracking, due to its potential impacts on human health and the environment.

RESEARCH ADMINISTRATIVE PERMITS 2005 - 2011



RESEARCH ADMINISTRATIVE PERMITS



CANTABRIA

•Cantabria is the 13º Autonomous Community in Spain in natural gas consumption, representing the 1,7% over the total volume of Spain.

•In this community, some research permits have been authorized; some of them involved other autonomous communities, such as ANGOSTO-1 (Burgos, Cantabria and Vizcaya), USAPAL (Cantabria, Vizcaya and Burgos); BEZANA-BIGÜENZO (Cantabria, Burgos and Palencia) and LUENA.

• ARQUETU permit has been concessed by the Cantabrian Government in 2011 to BNK España-Trofagás extending on a surface of 24.876 hectares.

•Investments within exploration phase in this community are around 100MEuros in the next four years.

PAIS VASCO

•Natural gas is the main energy resource in Euskadi, with an average of 39% of primary energy in the market (year 2011).

• Preliminary studies accomplished in Gran Enara deposit in the region of Alava (1.400 km2), show interesting data regarding the existence of relevant unconventional gas reserves. The deposit includes four administrative permits (Enara, Mirua, Usapal and Usoa). A group of several companies plans to make two exploratory drills in the area in order to determine the potential of Gran Enara.

•Works are currently in the phase of research and evaluation. The Basque Government will only consider a future exploitation phase in the case that the technical, economical and environmental viability of the project will be assured.

•The expected investment for this research is around 50M€.

CASTILLA Y LEON

•In this autonomous community the exploratory permits of Sedano and Urraca have been assigned to companies.

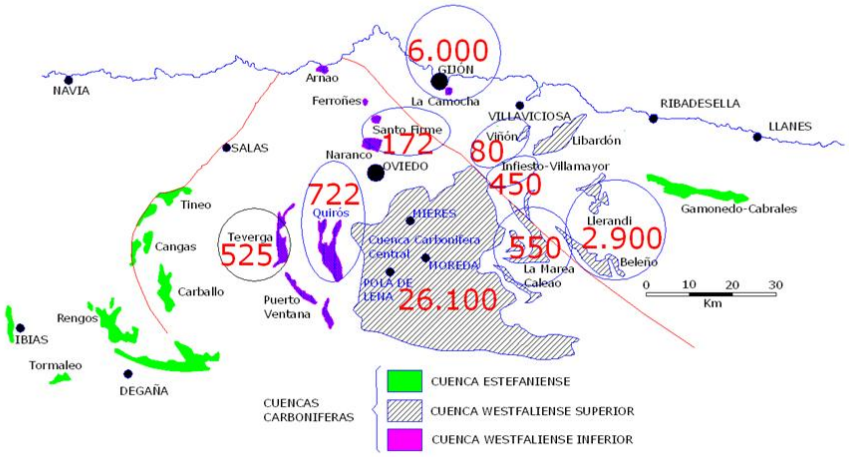
•The Urraca permits covers an extension of 94.815 hectares and Sedano 34.765 hectares.

•Investments, as a result from explorations in Castilla y León will be over 100M€ in the following four years.

ASTURIAS

- Despite Asturias presents interesting signs of hydrocarbons, exploration has been limited and intermittent: Six seismic campaigns with limited km and three drills: one of them, Caldones-1, with conventional objectives and the other two, Modesta-1 and Asturias Central-1, with an objective Coalbed Methane (CBM), with non conclusive results.
- Geology and exploratory results in Asturias confirm the potential of unconventional gas resources in this area: CBM, Shale Gas and Tight Gas.
- The volume of CBM Resources in Asturias is modest at a world level, but it is the biggest in Spain. According to the structure of the coal deposits with vertical beds it would be convenient to emphasize in the use of directional drilling and stimulation by hydraulic fracking.

CBM RESOURCES



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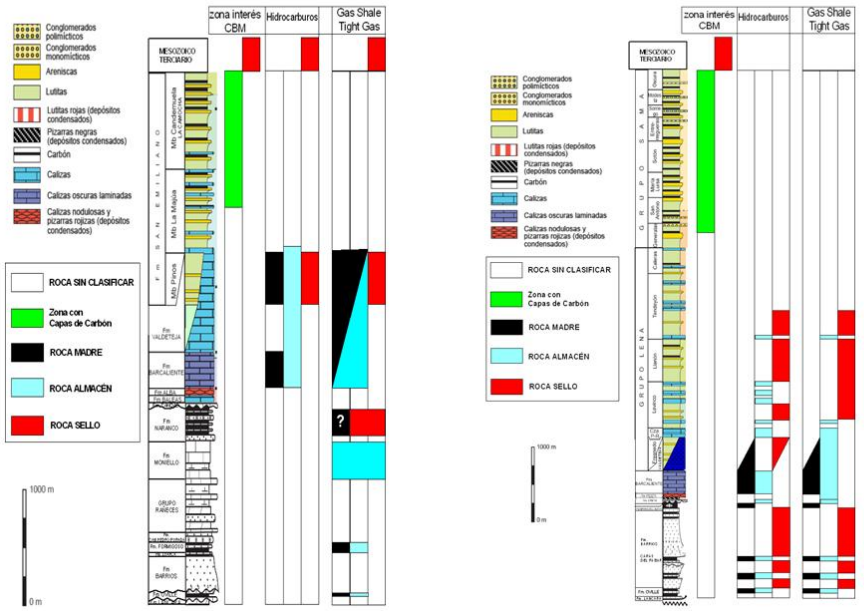
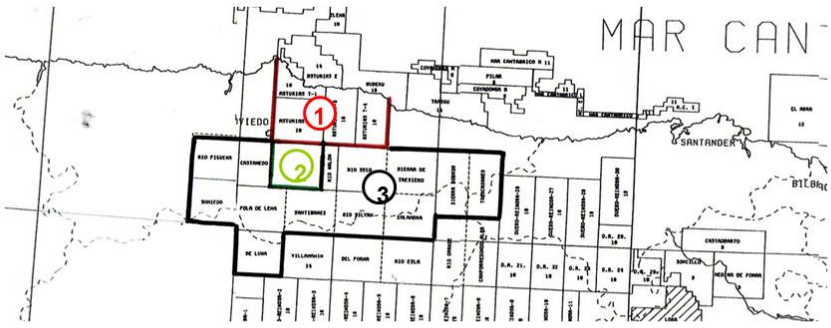
STRATIGRAPHIC COLUMN



RESEARCH PERMITS EVOLUTION

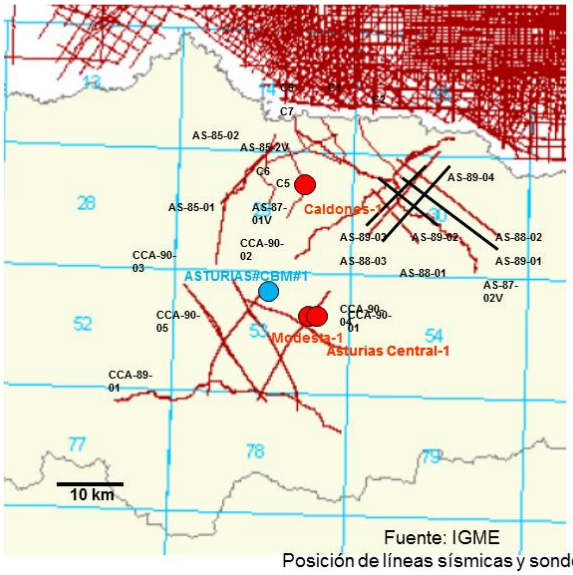


Permits in 1991				
Nº	Permits	Company	Concession	Renounce
1	Asturias T-1 + 3	Repsol	1985	1991
2	Asturias Central	Union Texas	1991	1997
3	Río Pigüeña + 16 más	Anschutz	1991	1997

(Fuente: ATH del MITYC)

EXPLORATION ACTIVITY

- Seismic
- Drills



Fuente: IGME
Posición de líneas sísmicas y sondeos

CBB EXPLORATION DRILLS

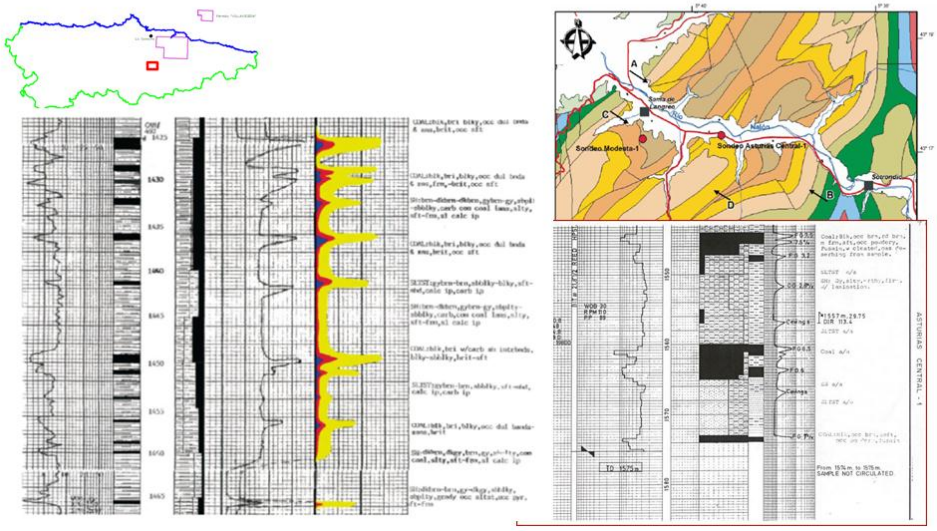
DRILL "ASTURIAS CENTRAL 1"

Depth: 1.575 m

DRILL "MODESTA-1"

Depth: 2.038 m

CBB EXPLORATION DRILLS



RESEARCH PERMITS EVOLUTION

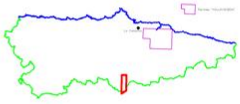
Permits in 2004			
Permit	**Company**	**Concession**	**Renounce**
Mieres	Heritage Petroleum	2002	-
Gijón	Heritage Petroleum	2002	2009
Campomanes	Hidrocarburos del Cantábrico	2004	2010
Monsacro	Hidrocarburos del Cantábrico	2004	2007
Lieres	Hidrocarburos del Cantábrico	2004	-
Laviana	Hidrocarburos del Cantábrico	2004	2010

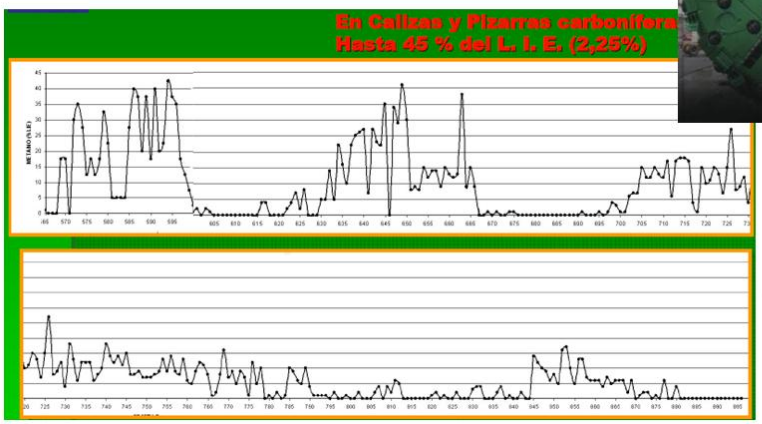
RESEARCH PERMITS EVOLUTION

Permits in febrero 2012		
Permit	**Company**	**Concession**
Mieres	Heritage Petroleum	2002
Lieres	Hidrocarburos del Cantábrico	2004
Villaviciosa	Petroleum Oil & Gas 70% Hunosa 20% Vancast Exploración 10%	2008
Morcin	Hunosa	2010
Granda	Petroleum Oil & Gas 50% Hunosa 40% Vancast Exploración 10%	2011

GAS SHALE IN PAJARES TUNNEL

GAS SHALE IN PAJARES TUNNEL





Gas: 25m3/t
Fm. San Emiliano

GAS SHALE IN PAJARES TUNNEL

UBICACIÓN	FORMACIÓN GEOLÓGICA	CONCENTRACIÓN MÁXIMA (% L.I.E. GRISÚ)
LOTE 1: La Pola de Gordón – Folledo (León)		
Túnel Este	Grupo La Vid (Pizarras)	3,5 %
	San Emiliano (Pizarras)	15,0 %
	Ermita (Areniscas)	5,0 %
	Huergas (Pizarras)	10,0 %
Túnel Oeste	San Emiliano (Pizarras)	44,0 %
	Pastora (Conglomerados)	5,0 %
	Huergas (Pizarras)	27,0 %
LOTE 2: Folledo – Viadangos (León)		
Galería de acceso de Buiza	Grupo La Vid (Calizas)	28,0 %
	Grupo La Vid (Pizarras)	30,0 %
	San Emiliano (Pizarras)	29,0 %
Túnel Este	San Emiliano (Pizarras)	38,0 %
Túnel Oeste	San Emiliano (Pizarras)	20,0 %
LOTE 3: Viadangos (León) – Telledo (Asturias)		
Túnel Este	San Emiliano (Pizarras)	47,0 %
LOTE 4: Viadangos (León) – Telledo (Asturias)		
Túnel Oeste	San Emiliano (Pizarras)	29,0 %

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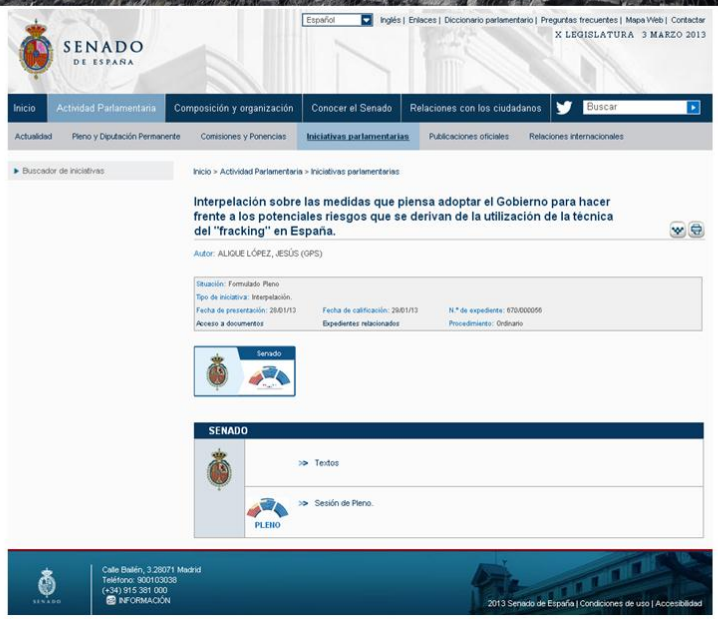
SOCIAL PRESSURE

- **Social pressure** of these movements has achieved to stop some of the research permits required or acquired, such as Arquetu, in Cantabria. In other cases, companies have rejected to those permits, as Porcuna (Jaén) or in mine basins from the North of the country (León and Asturias). There are recently several appeals against the authorization of the permits of Urraca (Burgos and Araba) and Esteros, Nava and Almorada (Albacete).
- Local Government of Vitoria has denied in September 2012 the two first permits to the company applying for Enara 1 and Enara 2 in the area of Subijana, although the applicants previously rejected to the drillings. Companies can apply for the permits in other locations; however, this fact shows the controversy regarding the use of fracking in Spain.
- Finally, it is important to emphasize the approval of the Law recently presented by the Government of Cantabria to prohibit hydraulic fracking in that region, both in exploration and exploitation activities. According to the Government, this measure will be effective until it is showed that this technique is not dangerous for health and the environment.
- The Government of the Principado de Asturias rejects fracking. In the Plenary Session of the February 8, 2013, it has been approved a proposal supporting the prohibition of hydraulic fracking in Asturias.

SOCIAL PRESSURE




Thanks very
much for your
attention

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11.6 UK shale gas, what we know, what we don't know

Nick RILEY, British Geological Survey

11.6.1 Abstract

The most prospective intervals for shale gas in the UK are in the Carboniferous and the Jurassic, which contain shales considered to be world class source rocks. The distribution of conventional oil and gas fields is a strong pointer as to where prospective shales are buried beneath younger cover. Exploration drilling (for shale gas) is in its very early stages and has targeted the “Bowland Shales”, in the Lower Carboniferous of NW England. This region has one of the thickest Lower Carboniferous sequences in the world, much of it deposited in hemi-pelagic facies throughout the Visean (Riley 1990) and early Namurian (Brandon et al 1998). A complex interplay of syndepostional rift/thermal sag tectonics, glacioeustasy and extra-basinal sourced gravity fed siliclastic and carbonate , has resulted in rapid lateral and vertical changes in thickness and lithology. Because of the lack of shale gas specific exploration data, early estimates of the resource (gas in place & possible recovery factors) have relied heavily on comparisons with experience from N. America (e.g. BGS 2010). What we do not know is how valid such analogies are. Not only because of the much thicker development of shale in the UK Carboniferous but also because of its intra- and post Carboniferous tectonic history. Without further exploration drilling and testing we will never know whether the “Bowland Shale” play is a unique and prolific shale gas resource or not. What is clear is that drilling access is going to more difficult than in N. America, due to regulatory & spatial constraints and hence targeting sweet spots is going to be of paramount importance. To enable this, explorers will require a very sophisticated geological understanding of this fascinating play.

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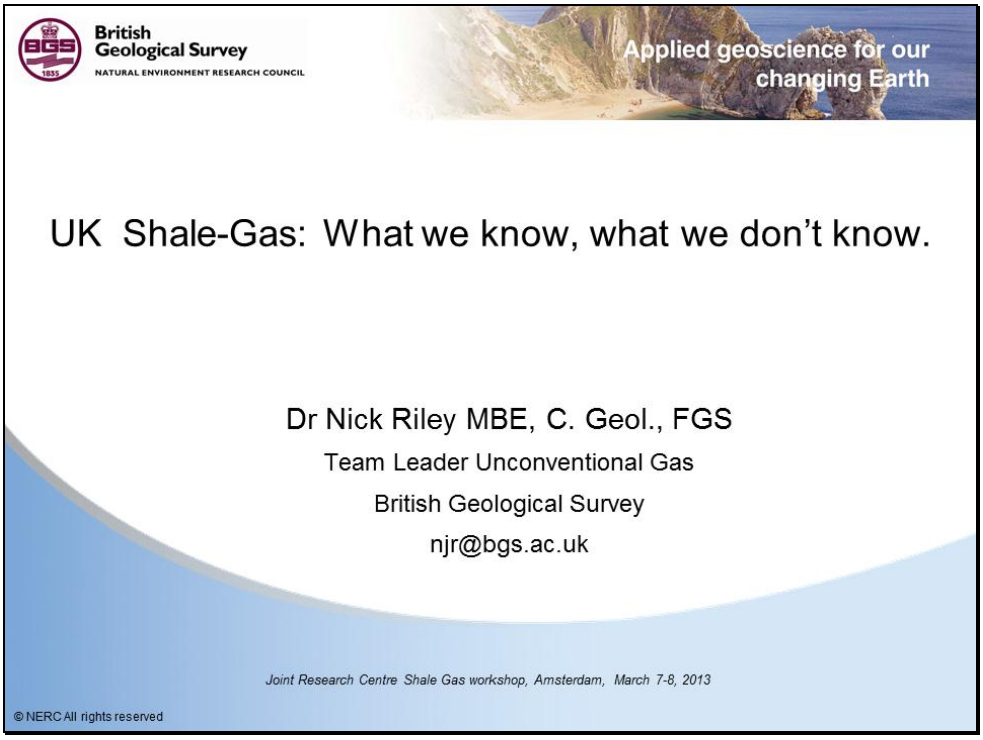
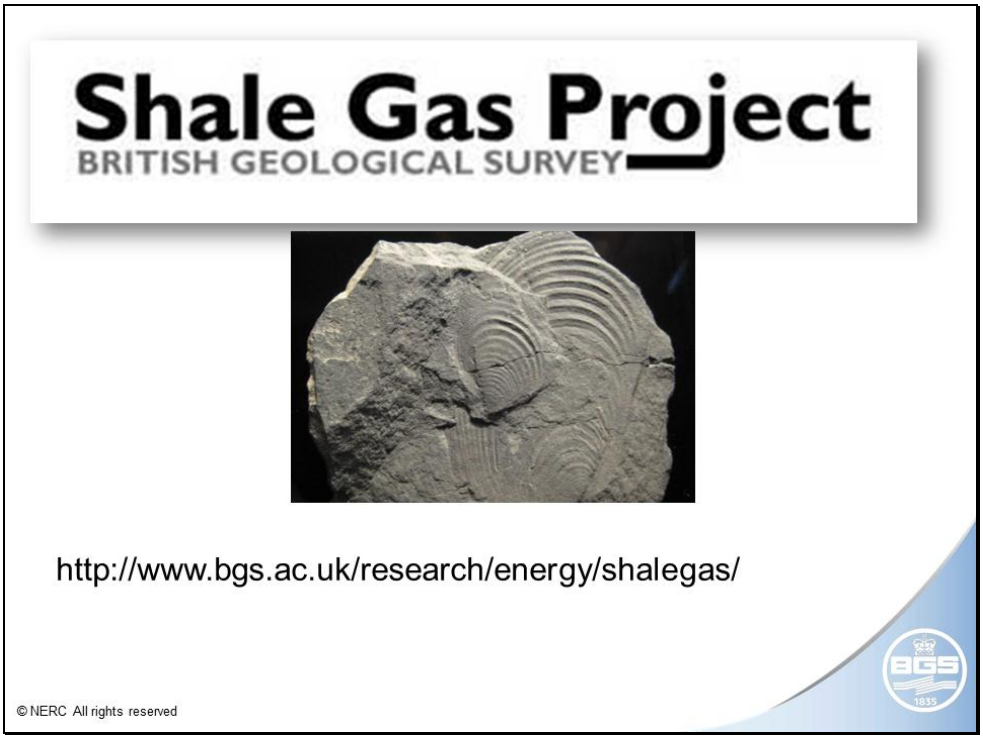
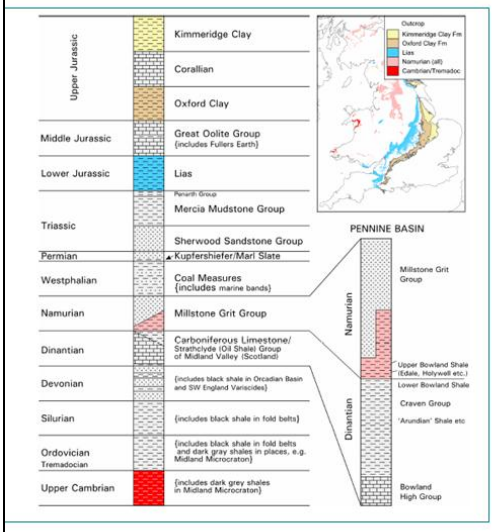
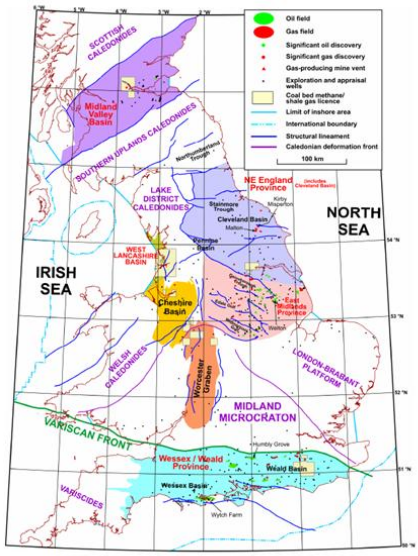
11.6.2 Presentation





UK Onshore Hydrocarbon Basins





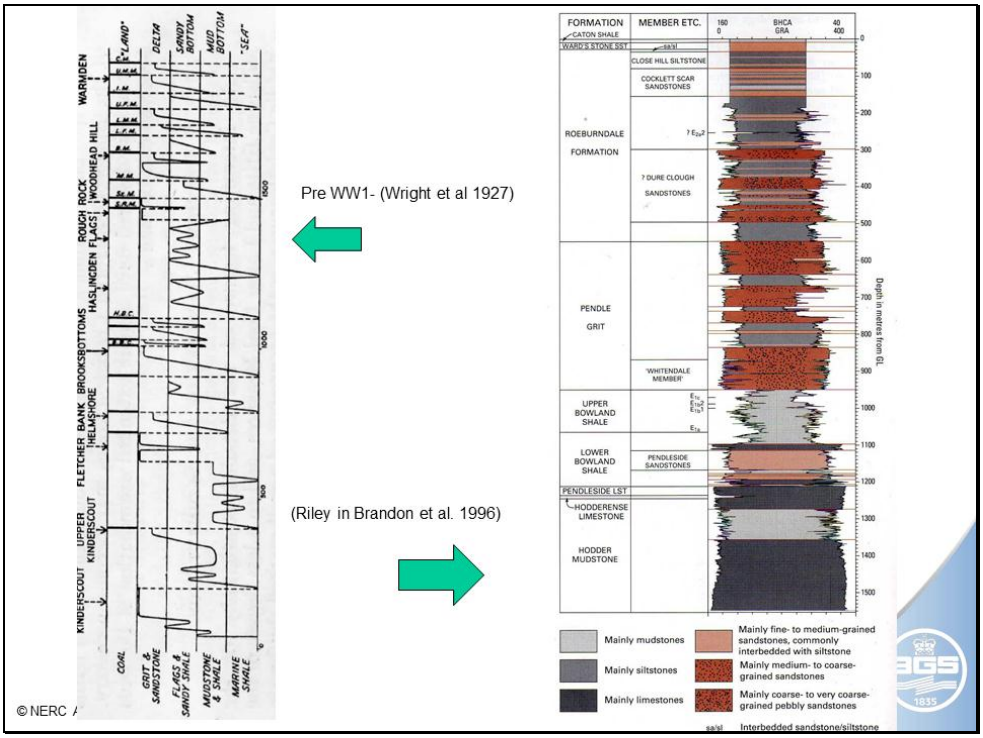
. 4 Principal UK onshore hydrocarbon provinces

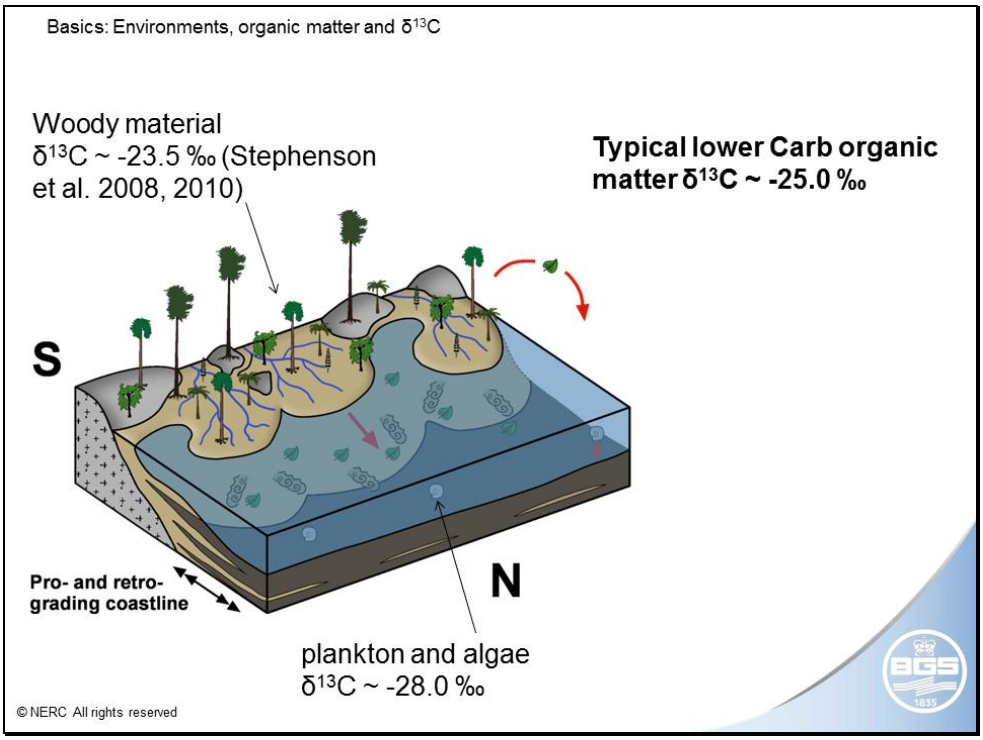
Table 2 Thickness and depth of UK shales of interest to shale gas extraction (Harvey and Gray 2010)

Formation thicknesses and depth vary widely across basins so all thickness and depth figures are generalised values. In A, 'gross thickness' refers to the entire shale and 'net thickness' refers to that part of the shale of particular interest for shale gas extraction (where known). In B, 'gross thickness' includes impermeable and permeable strata. 'Net thickness' refers to impermeable strata.

A Shales of interest in the UK			B Strata overlying these shales		
	Depths at which these shales are located	Shale thickness		Depths at which these strata are located	Thickness of these strata
JURASSIC					
Upper Jurassic, Kimmeridge Clay of the Weald basin	400 - 75m	600m gross 150m net	Weald Clay	Surface - 1000m	900m gross 600m net
Lower Jurassic Lias of the Wessex basin	Surface - 2000m	150m gross	Oxford Clay and Kimmeridge Clay (where preserved)	Surface - 2000m	660m gross 600m net
CARBONIFEROUS					
Bowland trough	1700 - 3100m	800 gross 250m net	Bowland Shale and Manchester Marl (MM)	3500m - surface (MM only)	700m (MM only)
Edale trough	Surface - 5000m	2000m gross	Edale (Bowland equivalent) and Namurian shales	5000m - surface	>2000m gross 1500m net
Widmerpool trough	1000 - 4000m	3000 gross	Bowland equivalent and Namurian shales	4000m - 500m	>3000m gross 2500m net
Gainsborough trough	200 - 4500m	2000 gross	Bowland equivalent and Namurian shales	2000m	1000m gross 500m net

royalsociety.org/policy/projects/shale-gas-extraction and **raeng.org.uk/shale**


WARNDEN
ROUGH ROCK
WOODHEAD HILL
HASLINGDEN FLAGS
BROCKBOTTOMS
HELMSHORE
FLETCHER BANK
UPPER KINDERSCOUT
KINDERSCOUT
"LAND"
DELTA
SANDY BOTTOM
MUD BOTTOM
"SEA"
COAL
GRIT & SANDSTONE
FLAGS & SANDY SHALE
MUDSTONE & SHALE
MARINE SHALE
Pre WW1- (Wright et al 1927)
(Riley in Brandon et al. 1996)
FORMATION
MEMBER ETC.
CATON SHALE
KAMES STONE SST
CLOSE HILL SILTSTONE
COCKLETT SCAR SANDSTONES
ROEBURNDALE FORMATION
? DURE CLOUGH SANDSTONES
PENDLE GRIT
'WHITENDALE MEMBER'
UPPER BOWLAND SHALE
LOWER BOWLAND SHALE
PENDLESIDE SANDSTONES
PENDLESIDE LST
HODDERENSE LIMESTONE
HODDER MUDSTONE
Depth in metres from GL
Mainly mudstones
Mainly siltstones
Mainly limestones
Mainly fine- to medium-grained sandstones, commonly interbedded with siltstone
Mainly medium- to coarse-grained sandstones
Mainly coarse- to very coarse-grained pebbly sandstones
Interbedded sandstone/siltstone


Basics: Environments, organic matter and δ13C
Woody material
δ13C ~ -23.5 ‰ (Stephenson et al. 2008, 2010)
Typical lower Carb organic matter δ13C ~ -25.0 ‰
S
N
Pro- and retro-grading coastline
plankton and algae
δ13C ~ -28.0 ‰
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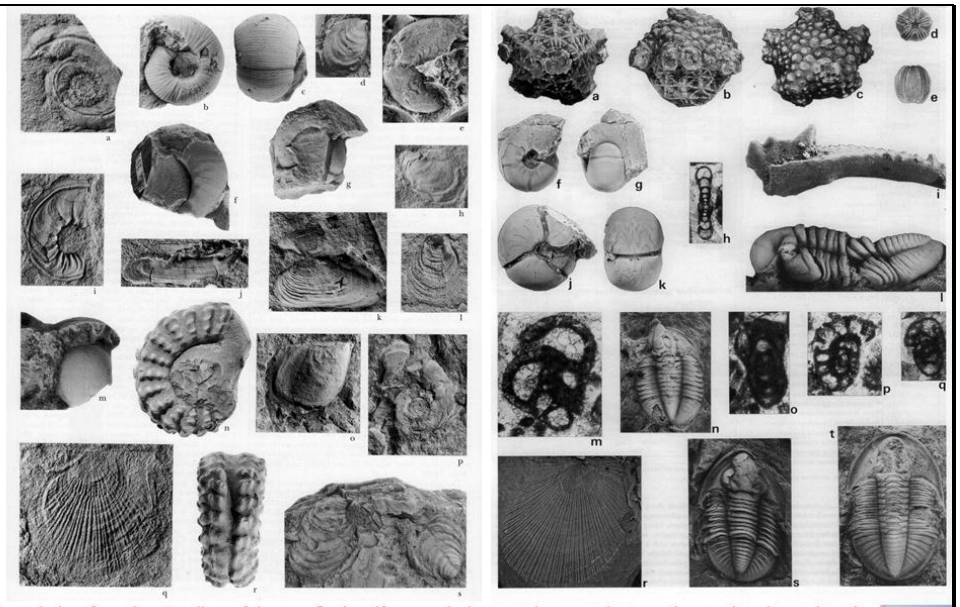


Correlation & understanding of Lower Carboniferous shales requires much more than palynology alone!
A strategic coring plan early in exploration will add value & remove much uncertainty & guide future plans

Glacioeustasy –
high stands correlated using ammonoids

PENSYLVANIAN (Lower)

As predicted from Europe this Interval is missing at Miss/Penn stratotype in Arrow Canyon USA – average global sea level very low across boundary interval. Sratotype does not comply with IUGS requirements

MISSISSIPIAN (upper)

Table 3 Ammonoid-based biostratigraphy and chronostratigraphy for the Namurian of north-west Europe. Regional non-ammonoid marine bands are omitted.

Stage	Genus-zone	Chronozone	Marine bands	Index	A	B
Yeadonian	Cancelloceras	G_{1b}	*Cancelloceras cumbriense*	$G_{1b}1$		
		G_{1a}	*Cancelloceras cancellatum*	$G_{1a}1$		
Marsdenian	*Bilinguites*	R_{2c}	*Donetzoceras? sigma*	$R_{2c}2$		
			Bilinguites superbilinguis	$R_{2c}1$	?*	
		R_{2b}	*Bilinguites metabilinguis*	$R_{2b}5$		
			Bilinguites eometabilinguis	$R_{2b}4$		
			Bilinguites bilinguis	$R_{2b}3$		MG
			Bilinguites bilinguis	$R_{2b}2$	?	
			Bilinguites bilinguis	$R_{2b}1$		
		R_{2a}	*Bilinguites gracilis*	$R_{2a}1$		
Kinderscoutian	*Reticuloceras*	R_{1c}	*Reticuloceras coreticulatum*	$R_{1c}4$		
			Reticuloceras reticulatum	$R_{1c}3$	?*	
			Reticuloceras reticulatum	$R_{1c}2$		
			Reticuloceras reticulatum	$R_{1c}1$		
		R_{1b}	*Reticuloceras stubblefieldi*	$R_{1b}3$		
			Reticuloceras nodosum	$R_{1b}2$	?*	
			Reticuloceras coreticulatum	$R_{1b}1$	?*	
		R_{1a}	*Reticuloceras dubium*	$R_{1a}5$		KbF
			Reticuloceras todmordenense	$R_{1a}4$		
			Reticuloceras subreticulatum	$R_{1a}3$		
			Reticuloceras circumplicatile	$R_{1a}2$		
			Hodsonites magistrorus	$R_{1a}1$		
Alportian		H_{2c}	*Homoceratoides prereticulatus*	$H_{2c}2$		
			Vallites ostriolatus	$H_{2c}1$		
		H_{2b}	*Homoceras undulatum*	$H_{2b}1$		
		H_{2a}	*Hudsonoceras proteum*	$H_{2a}1$	?*	
Chokierian	*Homoceras*	H_{1b}	*Isohomoceras* sp. nov	$H_{1b}2'$		
			Homoceras beyrichianum	$H_{1b}1$		
		H_{1a}	*Isohomoceras subglobosum*	$H_{1a}3$		CroM
			Isohomoceras subglobosum	$H_{1a}2$		
			Isohomoceras subglobosum	$H_{1a}1$		
Arnsbergian	*Eumorphoceras*	E_{2c}	*Nuculoceras nuculum*	$E_{2c}4$	?*	
			Nuculoceras nuculum	$E_{2c}3$		
			Nuculoceras nuculum	$E_{2c}2$	?*	Clau
			Nuculoceras stellarum	$E_{2c}1$		
		E_{2b}	*Cravenoceratoides nititoides*	$E_{2b}3$		
			Cravenoceratoides nitidus	$E_{2b}2$		CSh
			Cravenoceratoides edalensis	$E_{2b}1$		
		E_{2a}	*Eumorphoceras yatesae*	$E_{2a}3$		
			Cravenoceras gressinghamense	$E_{2a}2\alpha$		Rbl
			Eumorphoceras ferrimontanum	$E_{2a}2$		
			Cravenoceras cowlingense	$E_{2a}1$		
Pendleian		E_{1c}	*Cravenoceras malhamense*	$E_{1c}1$		
		E_{1b}	*Tumulites pseudobilinguis*	$E_{1b}2$		UBS
		E_{1a}	*Cravenoceras leion*	$E_{1a}1$		

Column A indicates the marine horizons recognised in the Lancaster district and column B their lithostratigraphical contexts. * denotes a non-ammonoid fauna in the Lancaster district.

K bentonite ash bands (from plinean, island arc source) provide independent correlation of glacieoustatic signature
Some silicification of shales at widespread horizons may be related to volcanism.

Table 4 The nature and timing of Carboniferous extension and subsidence.
Shaded areas represent periods of rifting.

Stages	Gawthorpe et al., 1989	Fraser and Gawthorpe, 1990	Memoir
Westphalian D			
Bolsovian		LC2	
Duckmantian			
310			
Langsettian		LC1c	
Yeadonian			
320			
Marsdenian			
Kinderscoutian			
Alportian		LC1b	
Chokierian			
330			
Arnsbergian			
Pendleian		LC1a	
Brigantian			
Asbian		EC5	
340		EC4	
Holkerian			
Arundian		EC3	
Chadian		EC2	
350			
Courceyan		EC1	
360 Ma BP			
latest Devonian			

Postextensional

Synextensional

Syn-rift to Thermal sag

Note : Extension period LC1b may well be confused with major global sea level fall (causing erosion at the basin margins and on surrounding "blocks") associated with the Mid-Carboniferous Boundary (=Mississippian/Pennsylvanian Boundary).

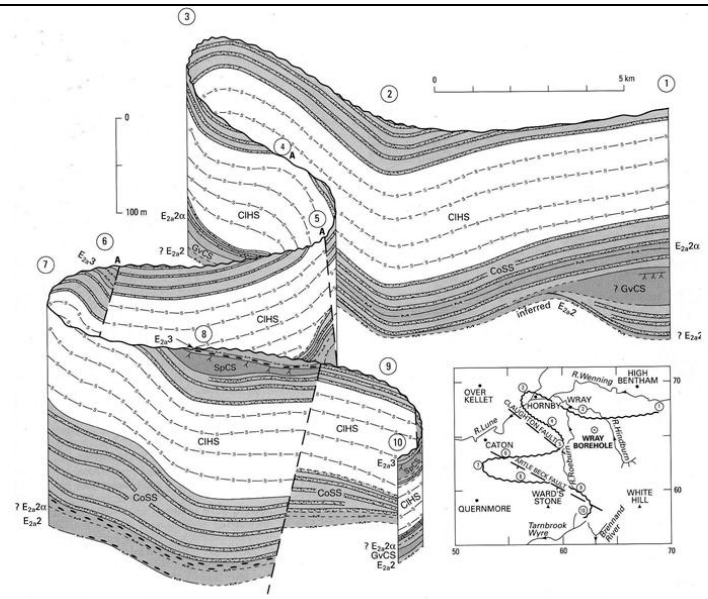


Figure 18 Ribbon diagram of the upper part of the Roeburndale Formation from the E. ferrimontanum Marine Band up to the unconformity at the base of the Ward's Stone Sandstone Formation. Selected faults which are thought to have partly moved prior to the deposition of the sandstone are shown. Note that the E. yatesae Marine Band is confined to locations south of the Artle Beck Fault. Localities where an angular unconformity is exposed are denoted by **A**. See Figure 19 for sections used to compile generalised stratigraphies about the locations numbered. Members are initialed as follows: Sapling Clough Sandstone, SpCS; Close Hill Siltstone, ClHS; Cocklett Scar Sandstones, CoSS; Gavells Clough Sandstone, GvCS. See inside

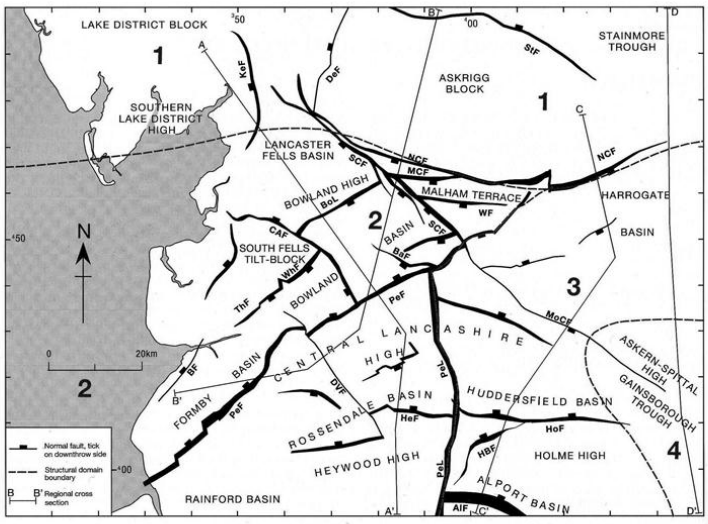


Figure 14 Principal early Carboniferous (synextensional) structures of the region.

AlF Alport Fault; Baf Barnoldswick Fault; BF Banks Fault; BoL Bowland Line; CAF Clitheroe-Abbeystead Fault System; DeF Dent Fault; DVF Darwen Valley Fault; HBF Herridge-Bradshaw Fault; HeF Heywood Fault; HoF Holme Fault; KeF Kendal Fault; MCF Middle Craven Fault; MoCF Morley–Campsall Fault; NCF North Craven Fault; PeF Pendle Fault System; PeL Pennine Line; SCF South Craven Fault; SfF Stockdale Fault; ThF Thornley Fault; WhF Whitewell Fault; WF Winterburn Fault.

1–4 structural domains

Lines A–A', B–B', C–C' refer to regional cross-sections accompanying structural maps at back of book.

UK Carboniferous shale gas basins are geologically very complex, especially in the synrift phase of deposition

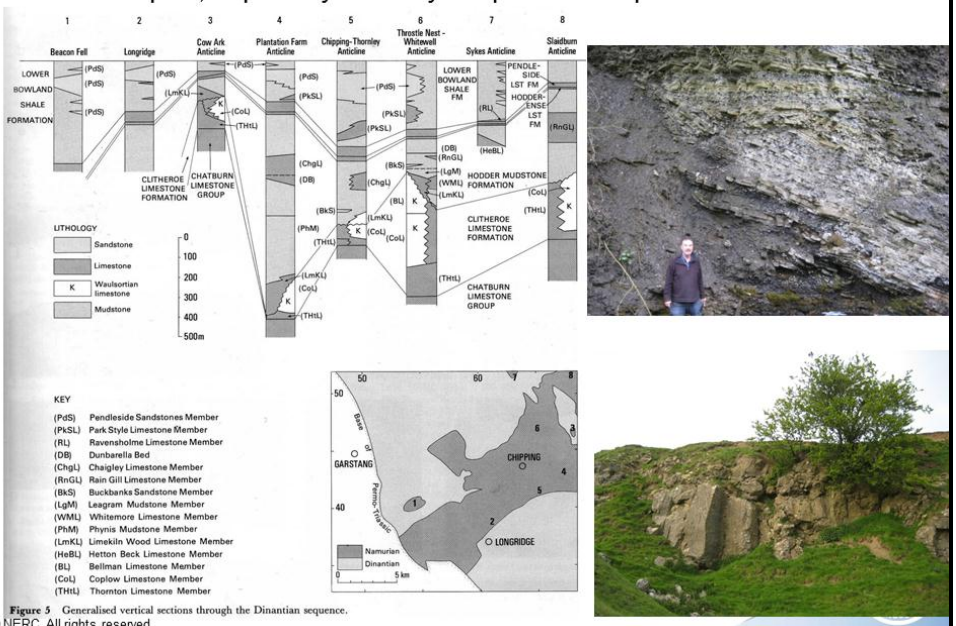


Figure 5 Generalised vertical sections through the Dinantian sequence.

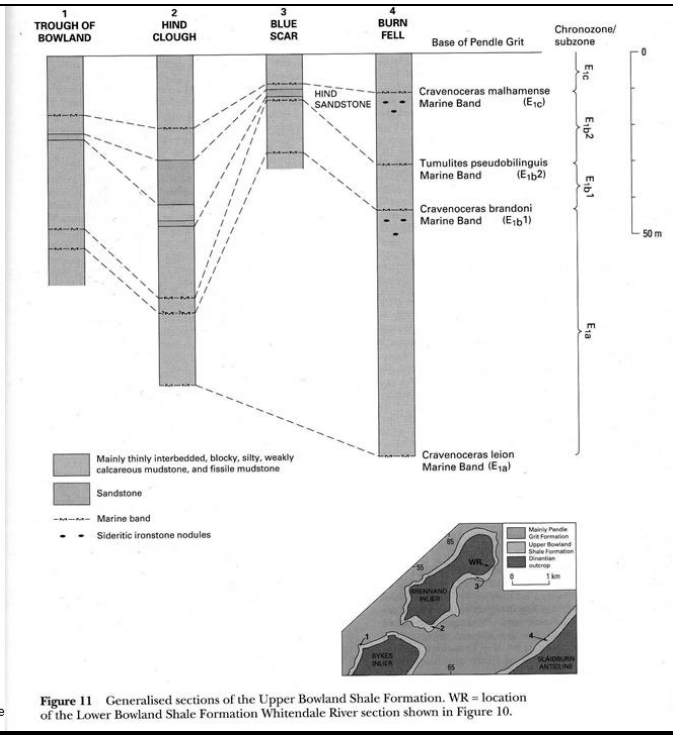
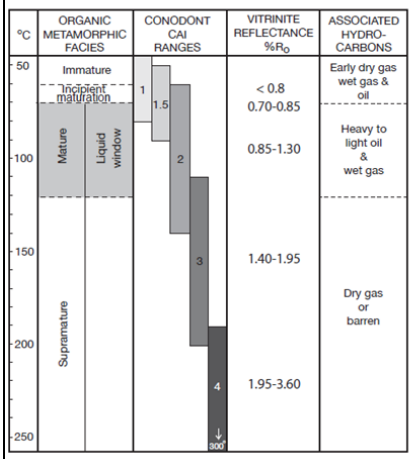
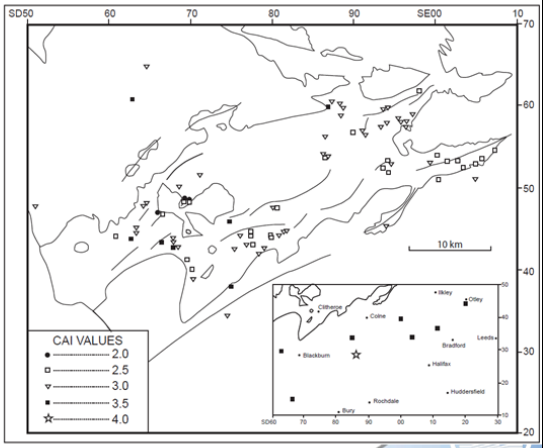


Figure 11 Generalised sections of the Upper Bowland Shale Formation. WR = location of the Lower Bowland Shale Formation Whitendale River section shown in Figure 10.

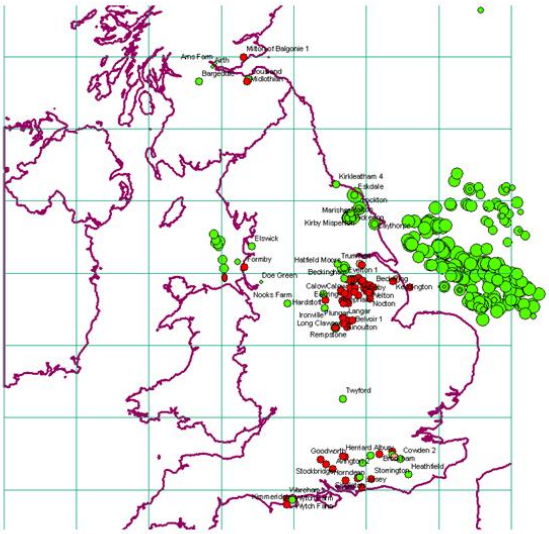
On palaeohighs in the Mid-Mississippian (e.g. in rift-basin margin reefs) there is no evidence that migrating hydrocarbons were trapped prior to the formation of burial cements

Craven Basin matured to dry gas phase by end Carboniferous (Metcalfe & Riley 2010)

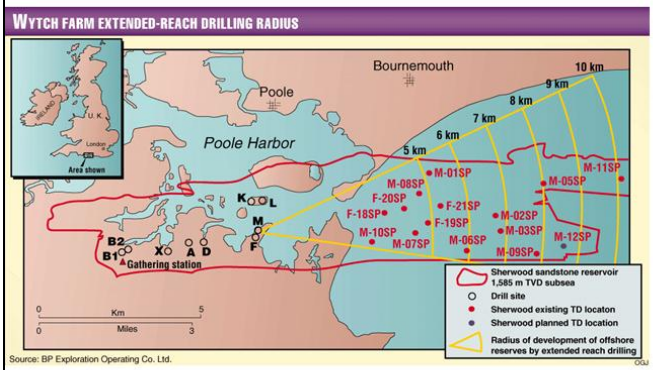




Shale gas exploration & conventional hydrocarbon discoveries are linked



Surface footprint USA –UK Compared – UK drilling access will be at a premium , so locating surface facilities to maximise sweet spots is essential.



The potential rewards from the UK Carboniferous are high, but explorers will require a very sophisticated **geological** understanding !

Special thanks to my BGS colleagues - Nigel Smith & Mike Stephenson,

BGS publications on unconventional gas related issues

- UK Coal resource and clean coal technologies (includes underground coal gasification, coal bed methane & abandoned mine methane)

http://www.bgs.ac.uk/downloads/start.cfm?id=1712

- UK Coal Bed Methane onshore resource

https://www.og.decc.gov.uk/UKpromote/onshore_paper/Promote_UK_CBM.pdf

- UK shale gas resource

http://og.decc.gov.uk/assets/og/bo/onshore-paper/uk-onshore-shalegas.pdf

- BGS webpage dedicated to shale gas

http://www.bgs.ac.uk/shalegas/

- Shale Gas - Seismic Risk, Monitoring & Management

http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/oil-gas/5055-preese-hall-shale-gas-fracturing-review-and-recomm.pdf

Recently the Royal Society published a useful report, on the request of the Government Chief Scientific Advisor, about shale gas extraction technology as applied to the UK. BGS assisted in this publication with sections about seismic risk/monitoring and groundwater monitoring.

http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/projects/shale-gas/2012-06-28-Shale-gas.pdf

Safety of Underground Natural Gas Storage (UK Health & Safety Executive)
http://www.hse.gov.uk/research/rrpdf/rr605.pdf

Map of natural geological radon affected areas UK in collaboration with the Health Protection Agency see
http://www.hse.gov.uk/radiation/ionising/radon.htm &
http://www.ukradon.org/article.php?key=indicativemap

We have recently announced the following on our web site in response to UK public concerns and shale gas.
Shale gas & radioactive waste disposal.
http://www.bgs.ac.uk/news/announcements.html#ni_1893
Shale gas and subsidence risk
http://www.bgs.ac.uk/news/announcements.html#ni_1862
Shale gas and regional stress
http://www.bgs.ac.uk/news/announcements.html#ni_1853

….and finally! You may ennjoy this cartoon?

http://www.youtube.com/watch?v=TKW4_UGVGBw&feature=player_embedded

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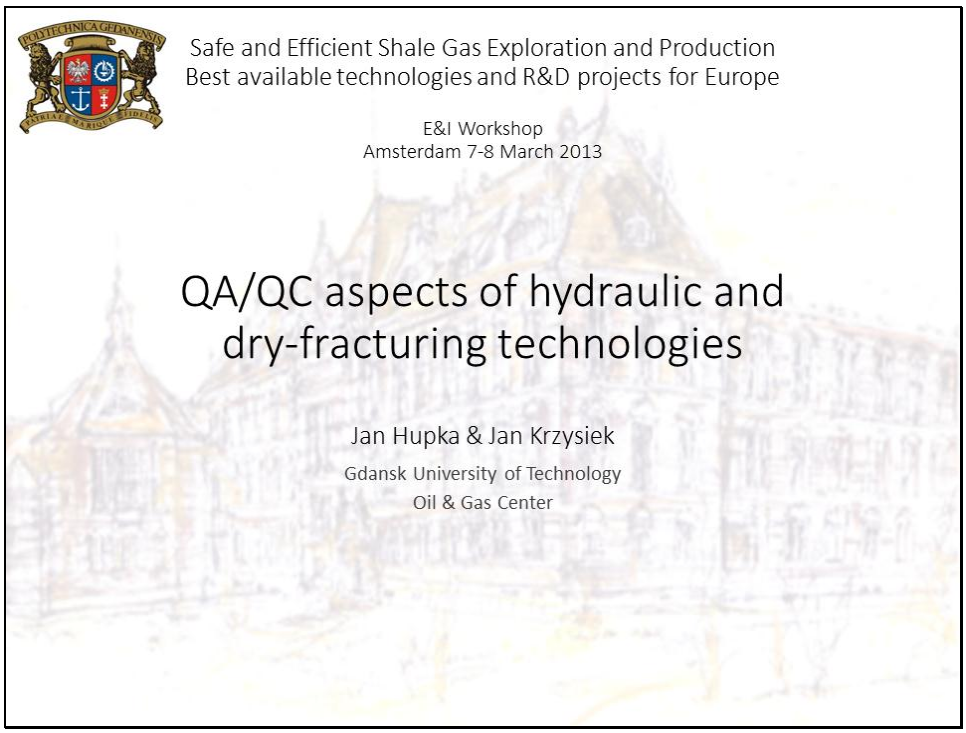
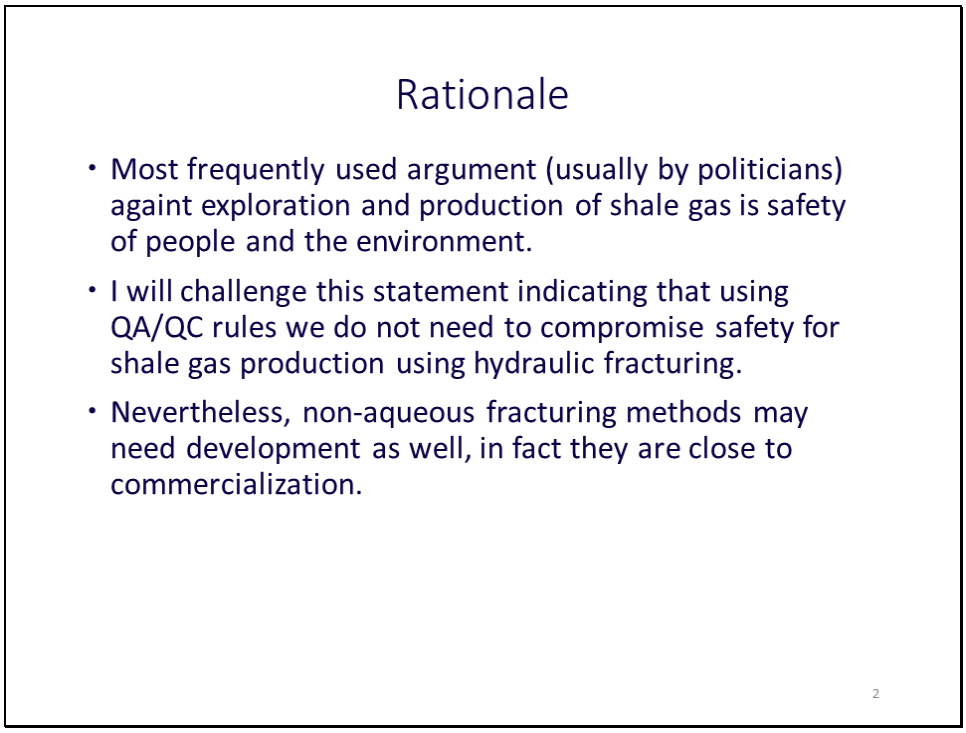
11.7 QA/QC aspects of hydraulic and dry-fracturing technologies

Jan HUPKA, Gdansk University of Technology

11.7.1 Presentation



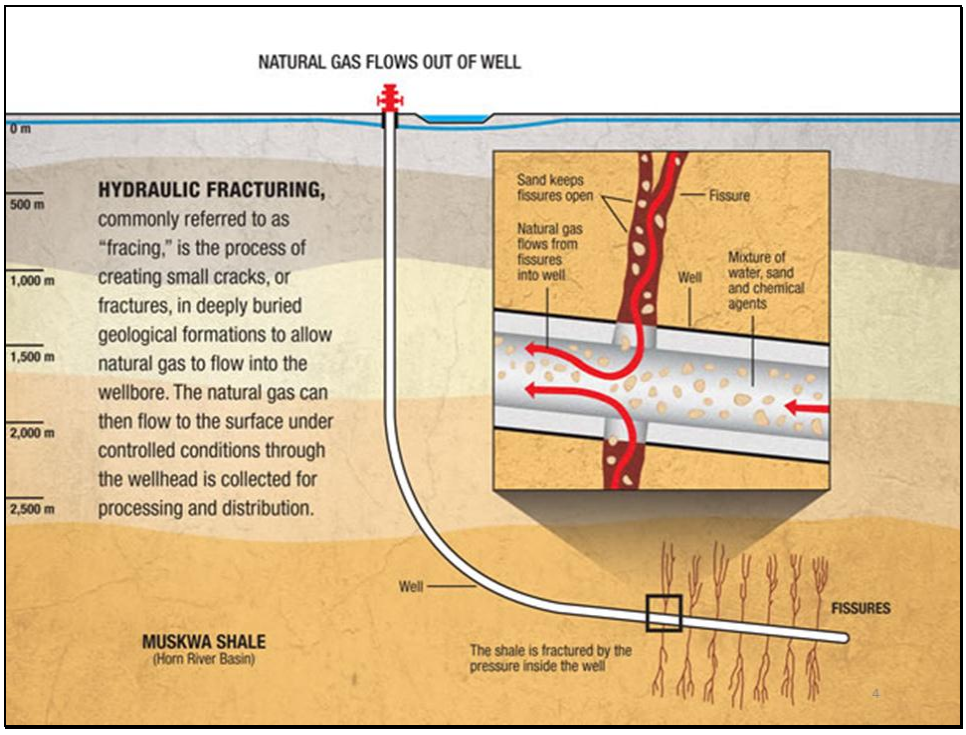


Actions of a company to solve quality problems

Quality assurance (QA) – planned and systematic actions essential to guarantee compliance with the quality of the final product in its creation.

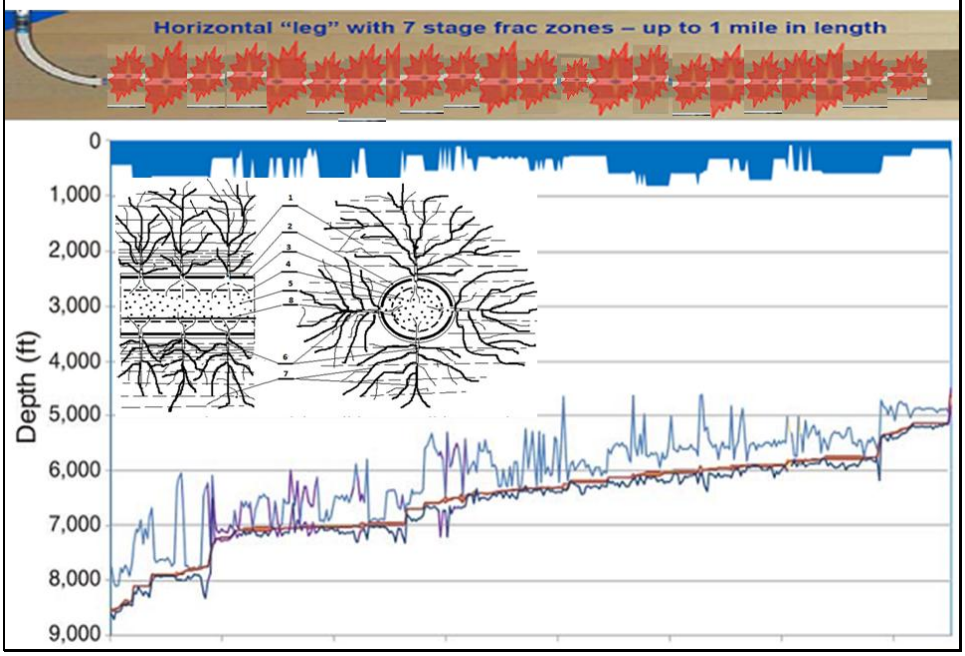
Quality control (QC) is an important factor decisive for the efficient production and safety for the environment and people. Those are the actions of the company to solve quality problems.

3

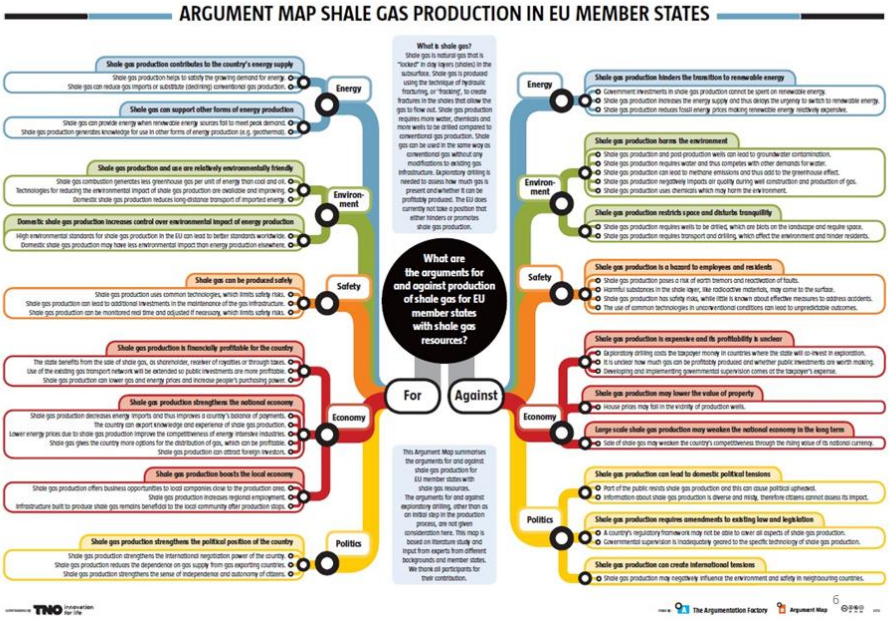


4

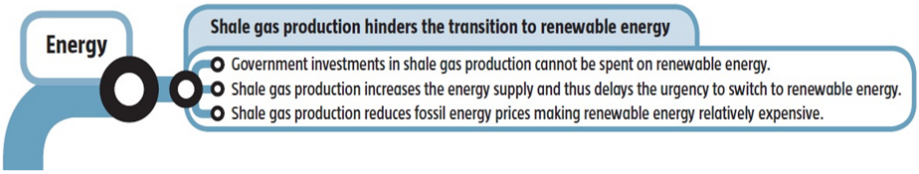
Dry Fracturing – Explosive Proppelant System (EPS)



Argument map - Glance from the Polish perspective



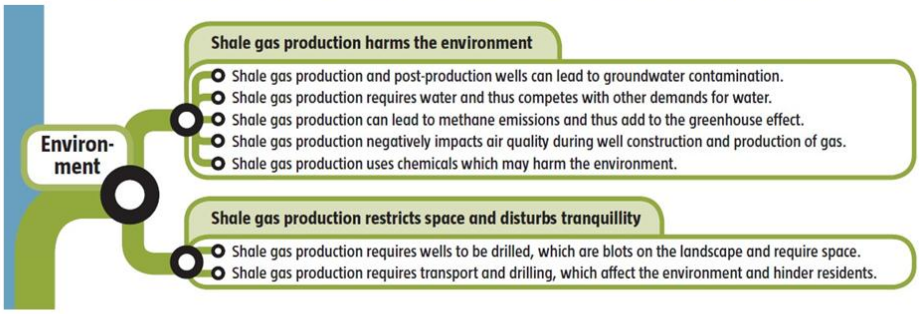
Argument map - Glance from the Polish perspective



- Investors in shale gas will not accept periodical gas supply concept when is only needed. Gas normally is stored in underground reservoirs as strategic reserve and for winter period. Return on investment is the ruling measure in shale gas as it is considered as very expensive to reach.
- Renewables in Poland's climate are difficult to be considered to be vital source of energy. Therefore, locally produced gas is considered as a versatile source in regional and local energy supply network, power generation and industry development needs.

7

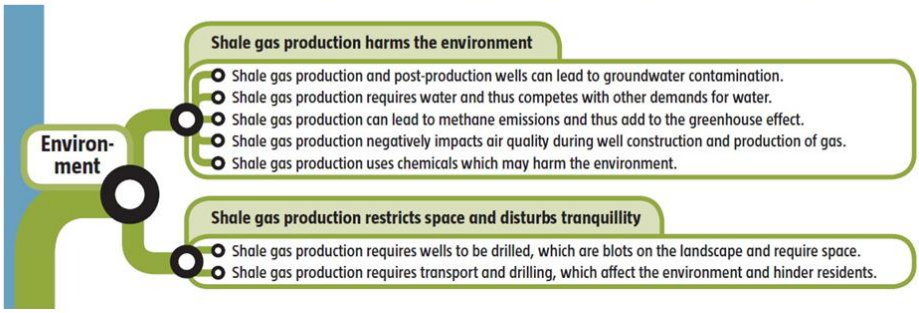
Argument map - Glance from the Polish perspective



- No reports from 5 basins in Poland of ground water contamination.
- In Pomerania sea water supply for fracking is in GUT project and Dry Fracturing EPS.
- Upstream and downstream installations are pressure tested and inspected for potential leaks. If leak is detected instalation is shut down, repaired and reinspected.
- Wrong. There is no difference to conventional well construction. Lack of evidence during monitoring in 5 basins in Poland.

8

Argument map - Glance from the Polish perspective

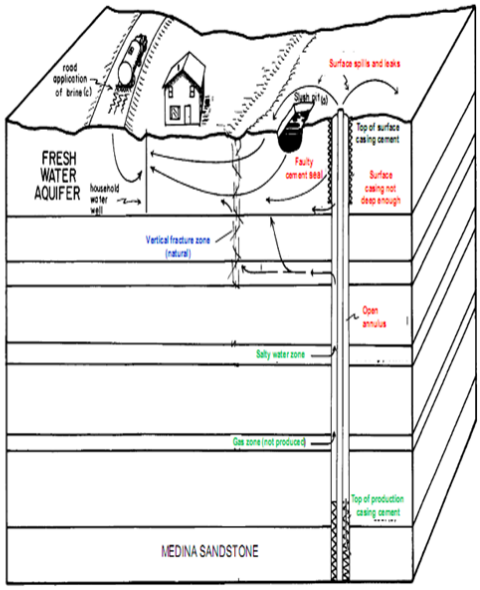


- Chemicals used are household grade and increasingly used environmet friendly.
- With development of lateral drilling systems in pads, the space is dramatically reduces as from single pad is possible to drill in excess of 20 wells with 60 laterals. Drilling noise is at level of country's road traffic. Only fracturing lasting 4 - 10 h from distance of 100 m is at 60 – 65 dB level.
- Transport and drilling consumes fuel also in any conventional drilling.

9

Potential Risk of Aquifer Contamination

- Casing leak
- No cement in production casing annulus
- Poor cement bond in production casing
- Free water in cement setting
- Poor cement bond in liner
- Frac fluid entry in production casing annulus
- Natural fracture accelerates upward fracture development
- Gas entry into aquifer and percolation to surface



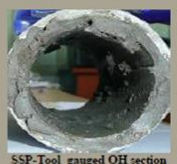
10

SSP-TOOL — SHALE CASING/LINER PROTECTOR

PATENTED SYSTEM

GUT
jankrzys@pg.gda.pl

SSP-Tool bullnose in instable wellbore



SSP-Tool gauged OH section

Shale sticking in OH to liner sections with shale packed around centralizers in expandable/swellable shale formation section.
In practice, mud circulation with pipe rotation nor cement spacer may not be able to wash away sticking shale. SSP-Tool may be forced with liner/casing into wellbore to required TD.

TECHNOLOGY THAT BRINGS NEW VALUE IN LINER/CASING RIH PROCEDURE IN REAL TIME.

Time Dependent Wellbore Instability in soft shale formations is a governing factor in successful RIH casing or liner, well performance and ROI: NPT prevention: to get stuck, POOH with casing, sidetrack?

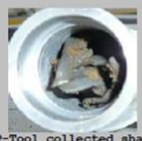
SSP-Tool is designed to protect RIH casing/liner from:

- Sticking soft-medium hard shale that to liner or casing surface (c
- Prevent sticking soft-medium hard shale to centralizers
- Secures hard and uncirculated cuttings to be cumulated in front casing shoe if tool is not RIH
- Reduces risk of cement chaneling and frac fluid & gas penetration along casing to aquifers

SSP-TOOL FEATURES AND BENEFITS.

- Secures good CBL/VDL to liners/casing in horizontal wells by gauging the hole
- Eliminates side track or cement squeeze job
- Option to RIH behind Guide Shoe or Float Shoe
- Reduces impact of OH ovality in soft to medium shale
- Open hole QC and NOGO signaled on ADT system to prevent of getting stuck during RIH and allows to circulate cut swollen shale
- Absorbs limited shale volume in body (SSP-Tools + Pup Joints)
- Reduces centralizers drag and wear
- Self-guided in horizontal hole
- Self-centralized and self-supported tool
- No movable parts
- Easy clean-up and reuse if POOH occurred
- Applicable for pre-perforated liners

SSP-Tool assembly RIH

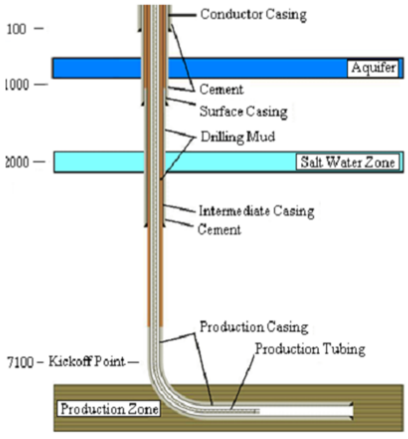


SSP-Tool collected shale

SSP-Tool Technical Support is advisable in last phase of drilling, clean-up to monitor ADT data, during liner/casing RIH, cement job and CBL/VDL survey.

11

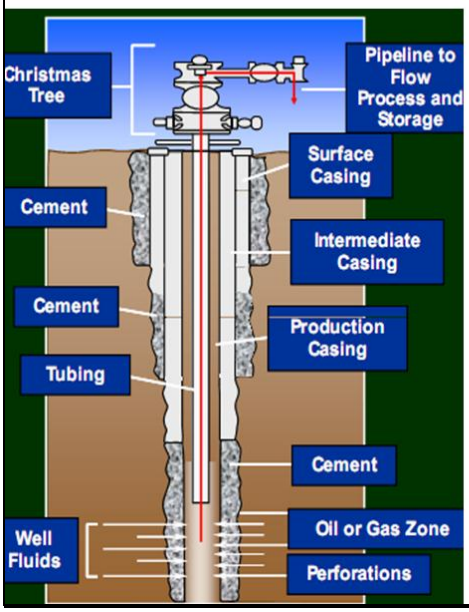
Drilling - Spudding the Well

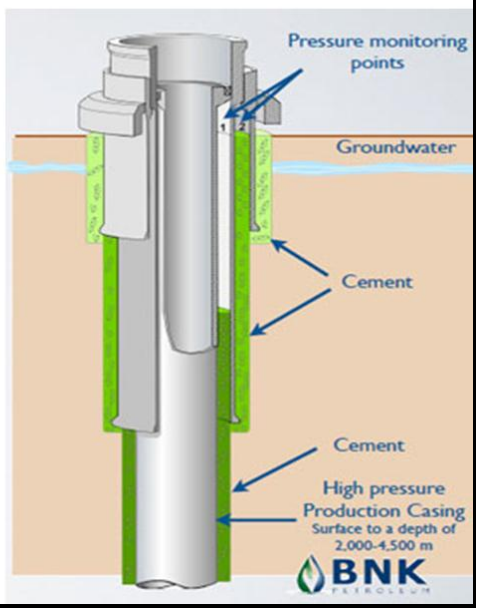


- Pre-spud meeting with all parties involved. Discussion all hazard and environmental issues. Contingency plan.
- Potential partial loss or lost circulation to aquifer.
- Should bentonite mud be used in conductor and surface casing?
- Water and mud sample taken prior to spudding.
- TOC and Cement top job.

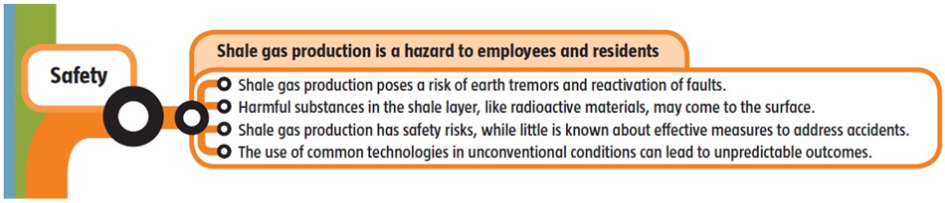
12

Cement and cementing quality





Argument map - Glance from the Polish perspective

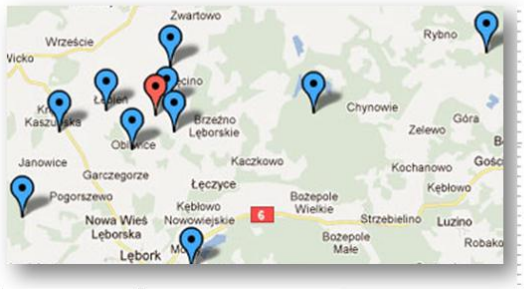


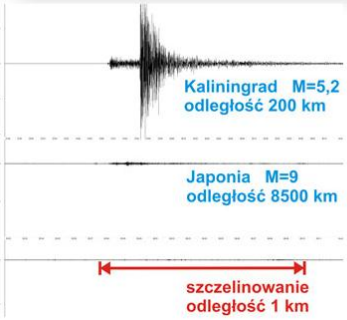
Not true:

- Lebien - 1 geological survey did not confirm any tremor.
- Tested drilling cuttings sample did not indicate increased radioactivity. Potassium 40 isotope is within our surrounding: cement and bricks. Granite has higher radioactivity than tested shale cuttings. Other radioactive isotopes are rare to be found in cuttings.
- Shale Gas has much lower pressure and produced volume than conventional. Gas production and transmission requires the same safety standards and strict inspections measures.
- Technology used is strictly as per API and ISO standards, QA/QC, standard operating procedure and regular inspection. Incidents frequency is no different than worldwide aircrafts.

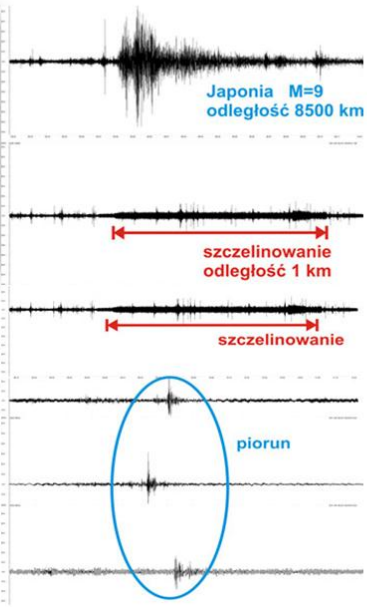
14

Induced seismicity

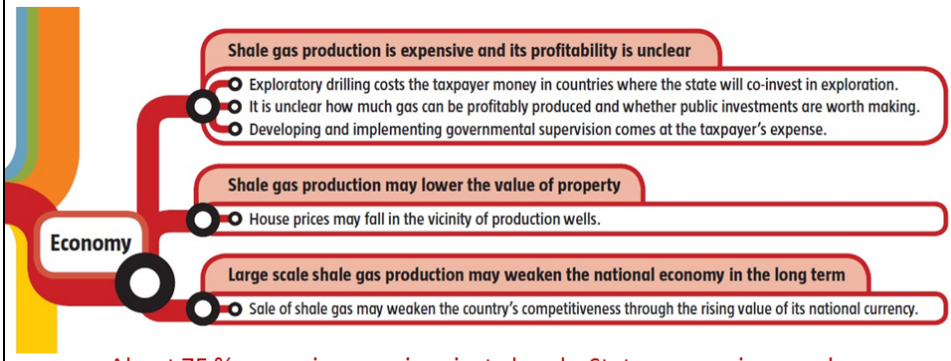




No quake in frac monitoring at Lebien. Lightning picks had been recorded and noise.



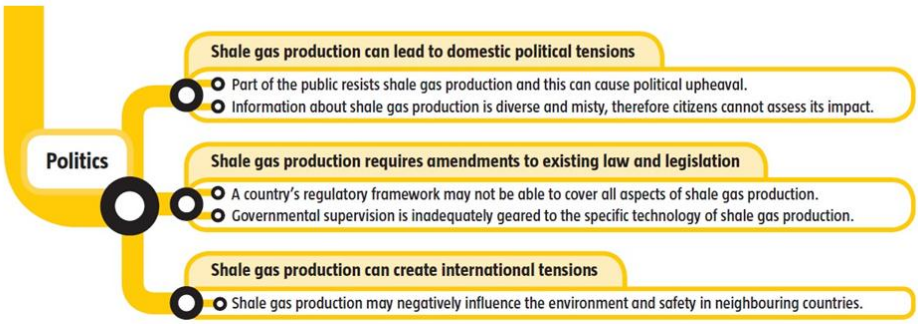
Argument map - Glance from the Polish perspective



- About 75 % concesions are in private hands. State companies are also profit oriented without state subsidy.
- No evidence of public investments in Shale Gas.
- Govenment institutions are at taxpayer's expense.
- No evidence worldwide except coal mining area.
  Dallas / Luisiana example. Producing wells are behind fences. Also in Carpathian Mountains region, south of Poland
- Wrong! It will speed up economical development and jobs place.
  Prosperous countries have always higher valued currency.

16

Argument map - Glance from the Polish perspective



- Poland's is constantly improving information flow and openness with cooperation at regional and local government level, universities and operators meeting with public.
- There is strong information exchange at government and scientific levels with world shale gas centers in USA at regulatory levels.
- Poland has a stricter regulations that USA and universities are monitoring and learning all encountered problems to prevent its occurrence in Poland and EU.
- Poland has international gas and oil pipelines and terminals for 45 years and is well experienced in supervision safety and environmental impact sensitivity.

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Hydraulic fracturing vs. dry fracturing

no.	Specification	Hydraulic Fracturing (HF)	Dry Fracturing (DF)
1	Frac fluid for single frac job	500 – 4000 m^3	0
2	Flowback	30 – 80 %	0
3	Compatibility of frac fluid with shale formation	Very important – crucial to the success	Does not exist
4	Ability of $CaCO_3$ removal	Pumped HCl – high	Produced HCl by gases – limited volume
5	Drillable packer	3 – 10 pcs.	0
6	Chemicals	Approximately 2 % of the frac fluid volume of fluid	0
7	Proppant	20 – 500 tones	0 - above 100 kg

Hydraulic fracturing vs. dry fracturing

no.	Specification	Hydraulic Fracturing (HF)	Dry Fracturing (DF)
8	Pumps units	8 – 30 ea.	0
9	Coil tubing	1	1
10	Staff on location	10 – 30 ea.	5
11	Fracturing duration	3 – 12 h	0,02 s
12	Fracturing geometry: vertical and horizontal	Absolutely unpredictable	In the x-section close to a circle
13	Horizontal and vertical frac range	Very high / 100 – 600 m / uncontrolled	Limited / 10 - 40 m round
14	Fracturing in the low thickness at sweet spot risk of formation water influx	NOT RECOMMENDED risk of hole loss	The only solution

19

Hydraulic fracturing vs. dry fracturing

no.	Specification	Hydraulic Fracturing (HF)	Dry Fracturing (DF)
15	Impact on the flow resistance	Very high (natural fissures)	None
16	Generated frac surface	Very high	Relatively low
17	Dependence of the stress according to the axis x-y-z	Very high	None
18	Induced formation stress	Problematic	Almost none
19	Tortuosity dependence	Very high	None
20	Creating fracture alongside of the casing axis - longitudinal	Almost always (Ali Daneshy)	None
21	Effectiveness of the perforation interval	30 % up to 5 - 2 %	100 %

20

Hydraulic fracturing vs. dry fracturing

no.	Specification	Hydraulic Fracturing (HF)	Dry Fracturing (DF)
22	Shale gas production / HF vs. DF / EPS requires testing	1	1 < comparable in terms of above mentioned parameters
23	Formation swelling because of the presence of smectite in soft clays – fluid-deposits compatibility	Assumed to be the main reason for the limited gas production	None / lack of water
24	Stress deposits blocking the propped fissure with flexible smectite	High risk	None
25	Type of formed fractures	Proppant propped / slip	Slippage
26	Fracturing cost	1	< 0,5 HF

Thank you for your attention.

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11.8 On the sustainable development of shale resource plays

Brian HORSFIELD, Helmholtz Centre Potsdam

11.8.1 Abstract

There are great opportunities for scientific and technological breakthroughs concerning the formation and extraction of shale gas. Technology has to be tailored to the geology, and the geology is very difficult to predict - no two shales are the same, either laterally (tens of kilometres) or vertically (tens of metres). Improved fracking and production allocation methods, as well as new integrated geological models are at the forefront of our research efforts. Transparency in operations (monitoring) and staying in close touch with all stakeholders are of paramount importance if technologically proven reserves are to be exploited. Of all the players involved, large research organizations uniquely stand out as the ideal foundation for honest brokering, including fact-based debate.

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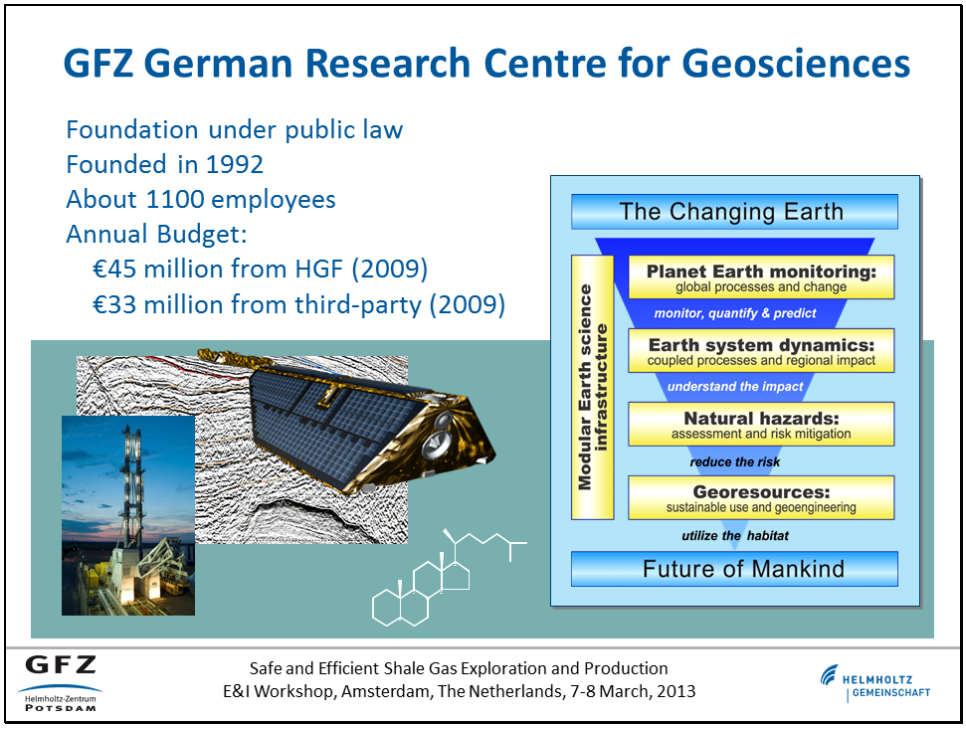
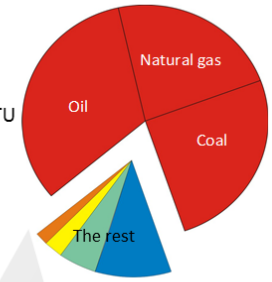
11.8.2 Presentation



Global Energy Perspective



2030
678 Quadrillion BTU
IEA Reference Case

- World population 8-12 billion by 2050, 50% in cities
- 40% more energy needed in 2035*
- Renewable energy growing but needs largely met by fossil energy!
- The unconventionals!
- Backcloth of global warming and the need for clean energy; and NIMBY for energy supply

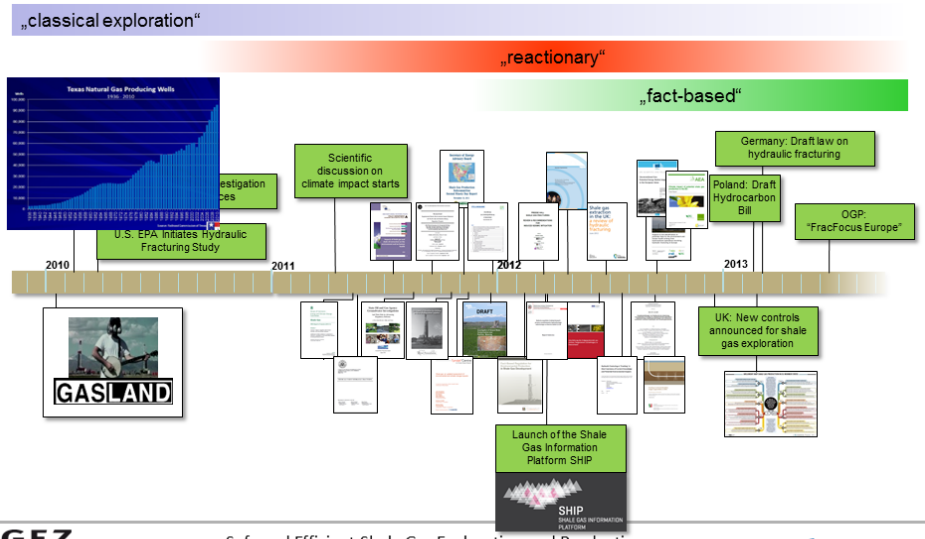
* "New Policies Scenario", World Energy Outlook 2011

Key challenges

- *maintain resource base for* ***economic growth***
  - *secure supply*
  - *enhance efficiency*
- *manage degree of* ***environmental and social impact***

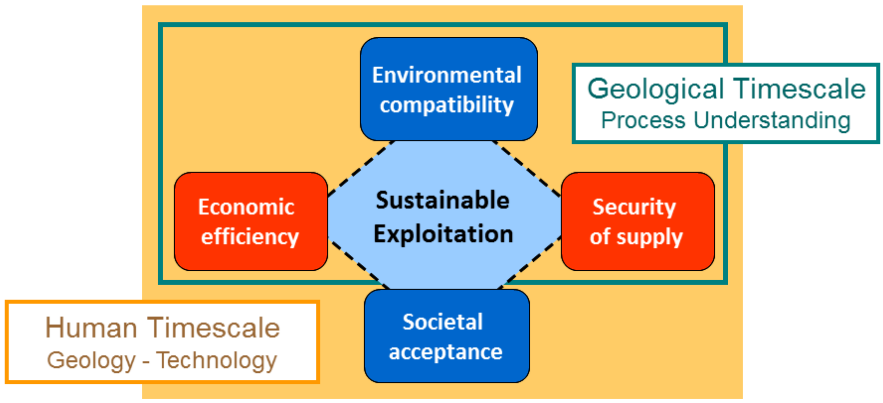
The long and winding road

To deploying environmentally compatible hydraulic fracturing in Europe



Sustainable developments

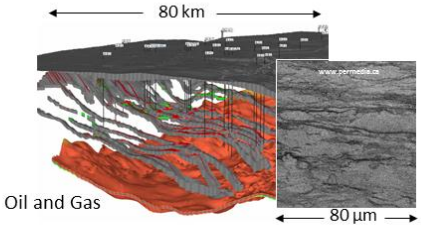
are defined as those that meet present needs without compromising the ability of future generations to meet their needs.



Research Categories

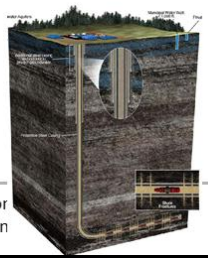
Emplacement: sources and sinks in a **geological** timeframe

*Focus is on the formation of fossil energy resources in **time and space;** chemical-physical-biological processes*

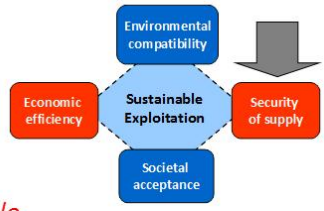


Exploitation: actions on a **human** timescale

Focus is on how resources are produced, and the ramifications for the environment (sensu lato)

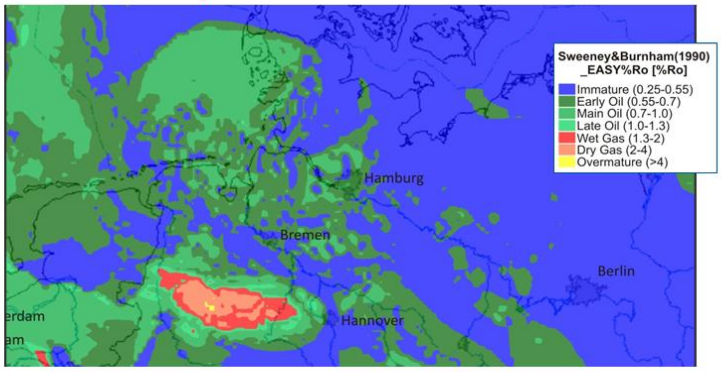


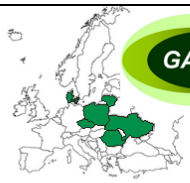
GASH



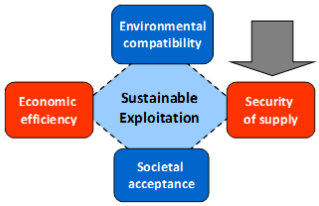
Lower Jurassic

Thermal maturity of the Posidonia Shale





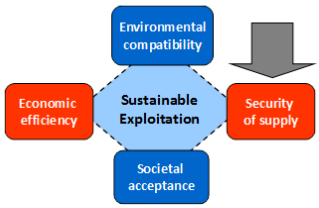
GASH-2



Ordovician/Silurian

- *Chronostratigraphic correlation across Denmark, Poland, Lithuania, Ukraine, Romanian and Czech Republic*
- *Identification of sweet spots in the Ordovician Silurian and delineation of shale gas plays*
- *Estimation of the sediment source areas and sediment flux calculations with description of the depositional environment*

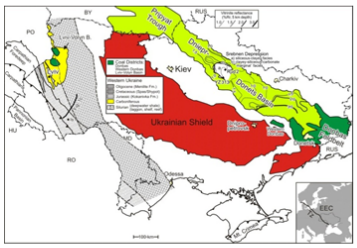
Present day distribution of Lower Palaeozoic strata

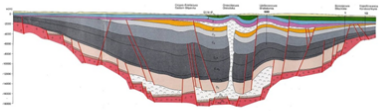


Lower Carboniferous

❖ *Investigation and comparison of "Visean key sections" in different parts of the Czech and Polish parts of the Variscan Foreland, and the DDB (UA)*

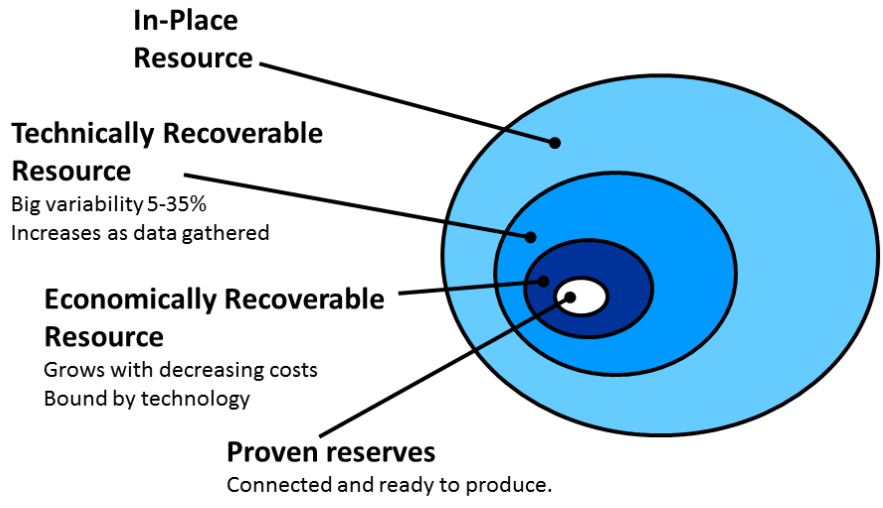
❖ *Investigation of the controls on lateral and vertical facies variations of the most important Visean black shale horizon (Rudov Beds in the DDB)*





Resources versus Reserves

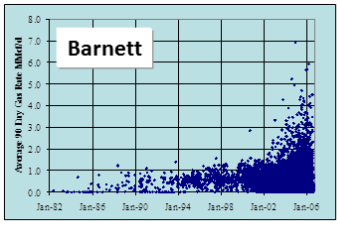
(Rice University Website)



An Industry Perspective - The Need for Research

"There is no instant success and there is no eureka moment"
Michael Binnion, CEO Questerre, MPG 2012

Based on Data From Lasser Production Data (R. Moorman)

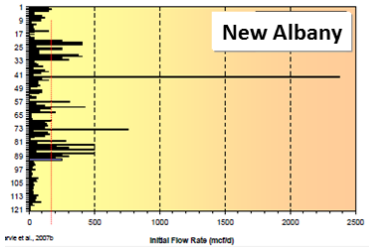


Conventional gas exploration

- drilling the best wells first is the goal

Shale gas exploration

- Results improve over time
- Trying to skip the learning curve and drill the best wells doesn't work and wastes capital
- Acquire a statistically significant set of results
- Test one variable at a time



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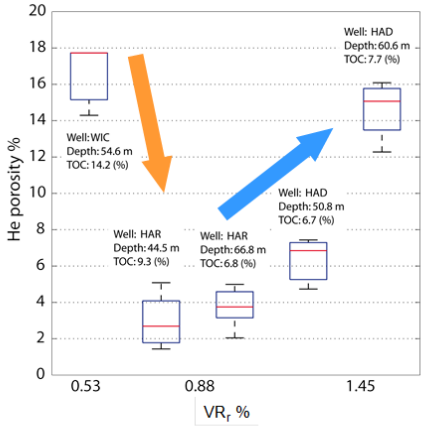
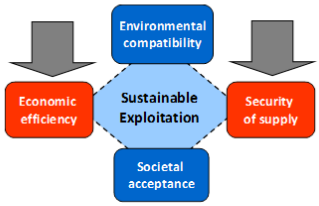
Porosity development

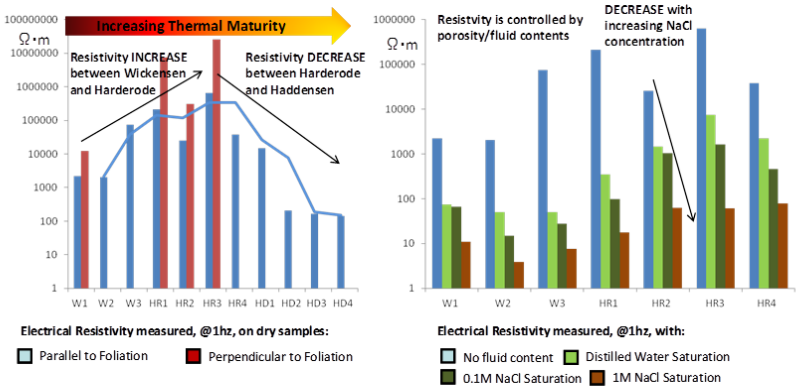




Porosity Loss through Oil Window
Porosity Gain in Gas Window

Electrical Resistivity Measurements of Black Shale Samples from the Hils Syncline, Germany

- Black shale samples are generally electrically resistive and anisotropic
- No simple relation between electrical resistivity and TOC/Ro
- Porosity / permeability and NaCl / water content are the controlling factors for electrical resistivity.



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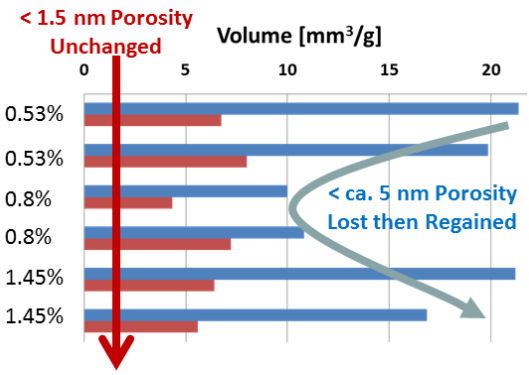
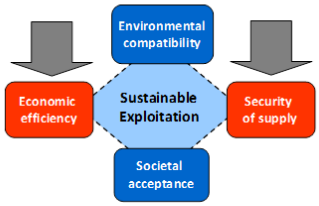
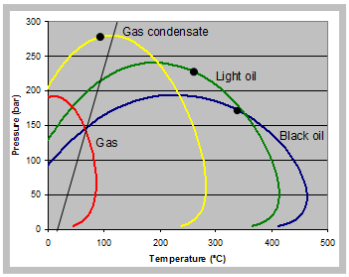
Porosity Classes

Coutesy of Andy Aplin, Newcastle University





Fluid Properties



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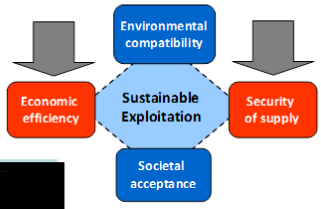
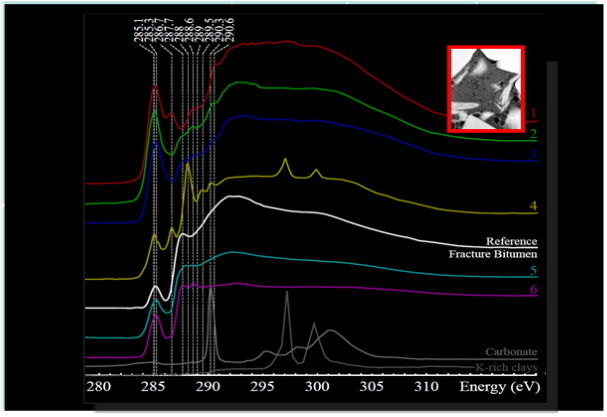
Organic Matter Composition





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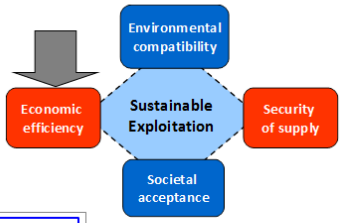
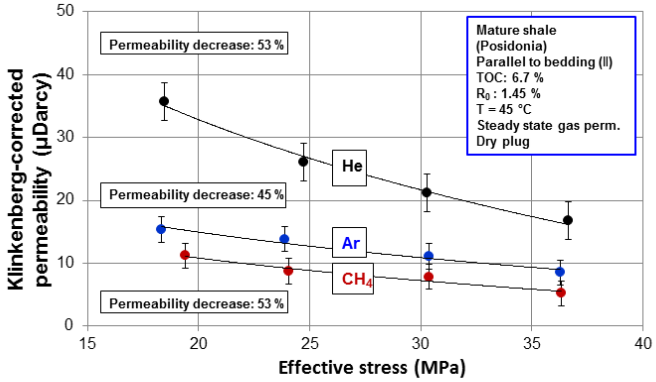
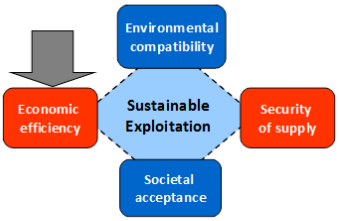
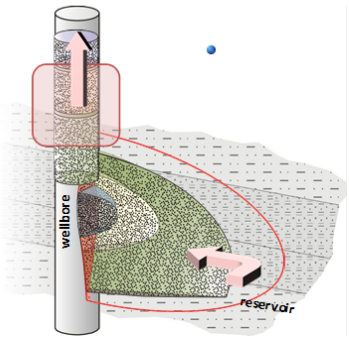
Gas Permeability





Fracking Technology





Fracturing efficiency
- hydrofracture nucleation,
- inelastic creep
- micro-seismic wave analysis and downhole data transmission
Production allocation
- which zones yield what

European Dimension

Funding by Industry

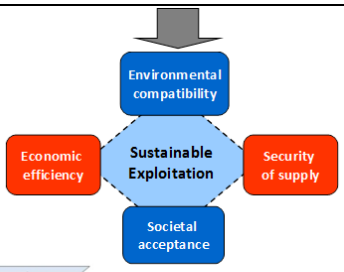
Full transparency
Funding of students
Publication of results

Sciences

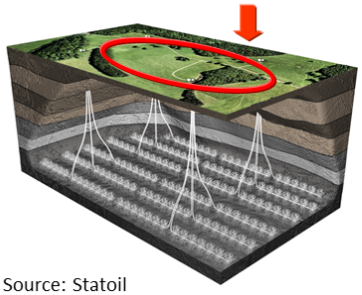
Surveys

Sponsors

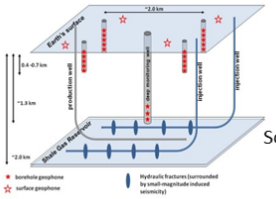
Monitoring at industry fracking sites



Shallow horizons being studied



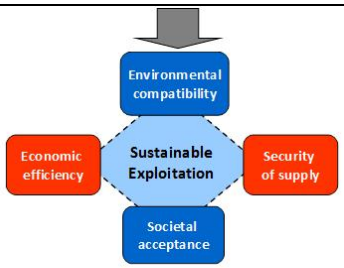
Source: Statoil

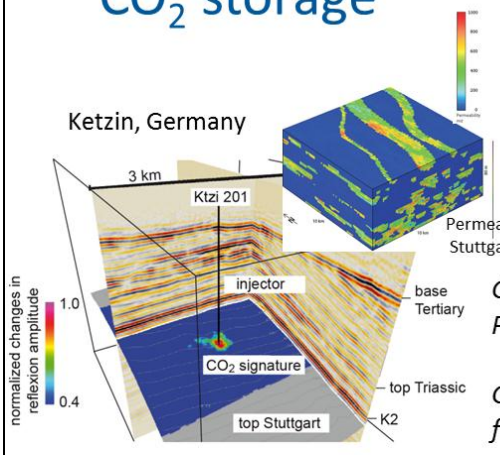


Source: Bohnhoff, GFZ

Potential leakage – deep to shallow
Potential contamination by leachates (metals and organics)
Induced seismicity

Know-how from CO_2 storage



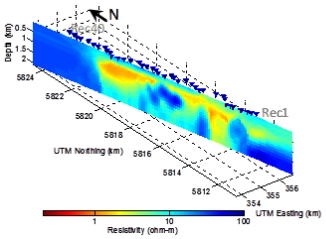


Courtesy of Axel Liebscher, GFZ-Potsdam

Greenhouse gas storage attributes
Potential leakage – deep to shallow

Geophysical monitoring and predictive fully coupled modelling

New Research Opportunities



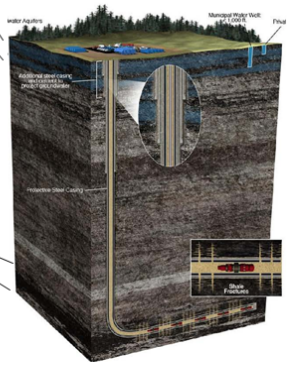
Courtesy Oliver Ritter, GFZ-Potsdam

Shallow systems

The new frontier

separating traditional disciplines

Deep systems



Source: Chesapeake

Pure....

Heat budget
Hydrofracture propagation
Inelastic creep
Kerogen structure
Reaction kinetics
Partition/phase behaviour

Applied....

Reservoir continuity
Petroleum quality
Production allocation
Gas in place
Frackability
Seal integrity

Falling between the cracks

pun intended

Economic aspects....

- Europe has leading institutions for shale gas science and technology
- Best practice could bring homegrown resources on line
- A new global export to China, South America and the rest of the world
- Industry partnerships ongoing – transparent and beneficial to all

Environmental aspects....

- Industry provides site as natural laboratory
- Industry provides no funding of academics
- European Union must fund academia
- Build European database
- National funding agencies fund intranationally

European Dimension

Funding by Europe

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11.9 Modelling of large scale field developments

Mathias MITSCHANEK, Mining Univ. of Leoben

11.9.1 Abstract

This presentation focuses on a model, describing all pertinent operations of a shale gas field development. Scenario planning, social and environmental impact studies, and economical analysis will be the major scope of the project. Introducing the model, the status quo and an outlook of future activities will be the topics of this talk.

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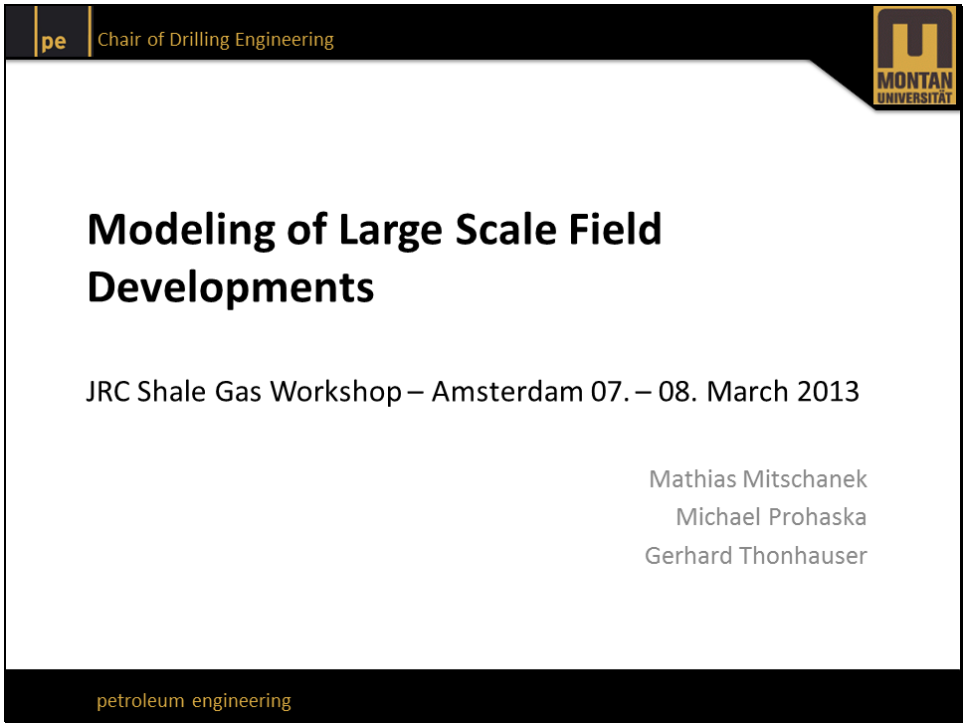
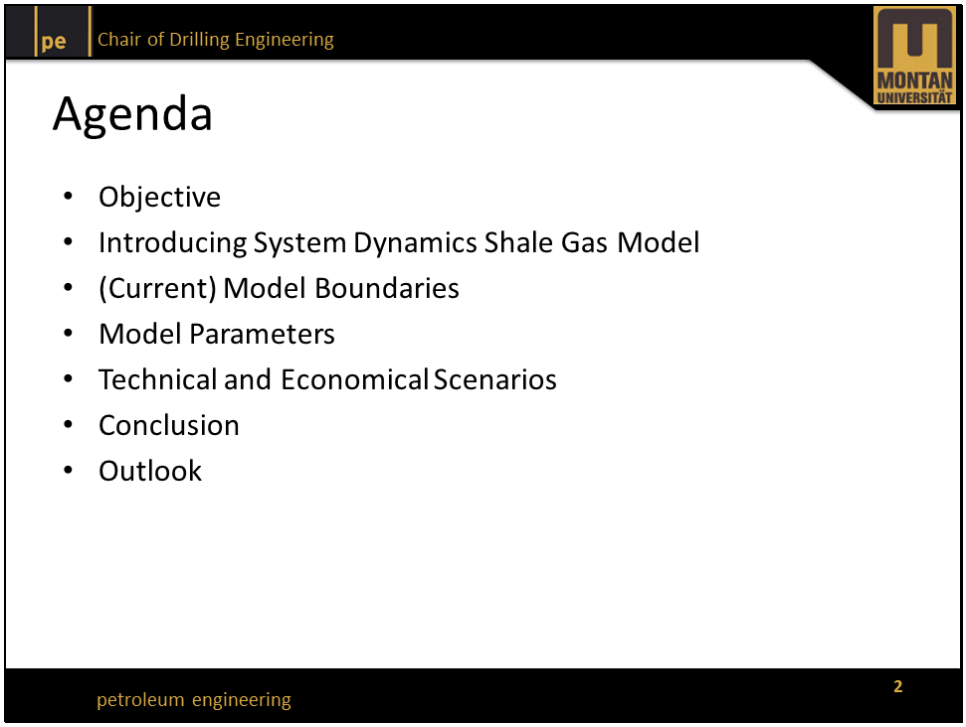
11.9.2 Presentation



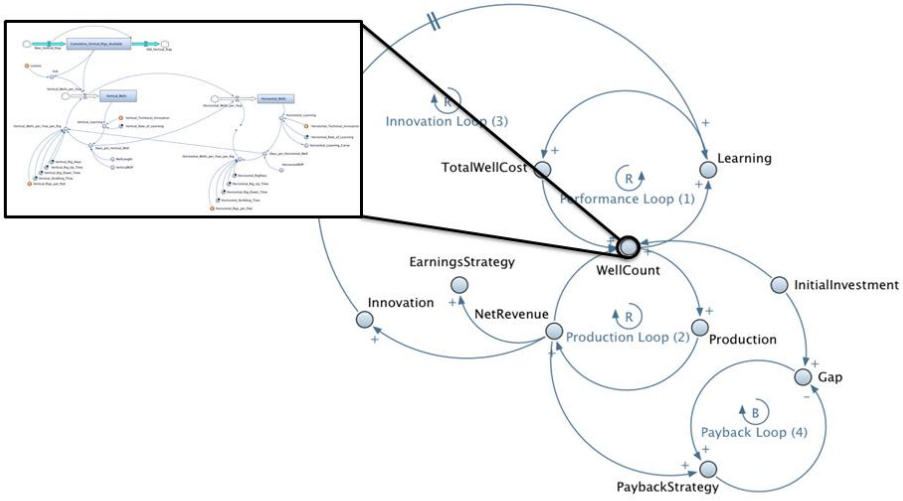


Objective

- Study field development dynamics in specific areas
- Define quantitative dependencies between variables and effect on outcome
- Compare different field development strategies
- Find potential regional/countrywide,… social impact
- Analyze environmental impact and define strategies to minimize it
- Analyze economic impact and define strategies to optimize it

…all achieved by System Dynamics modeling in combination with geographic maps

System Dynamics Shale Gas Model

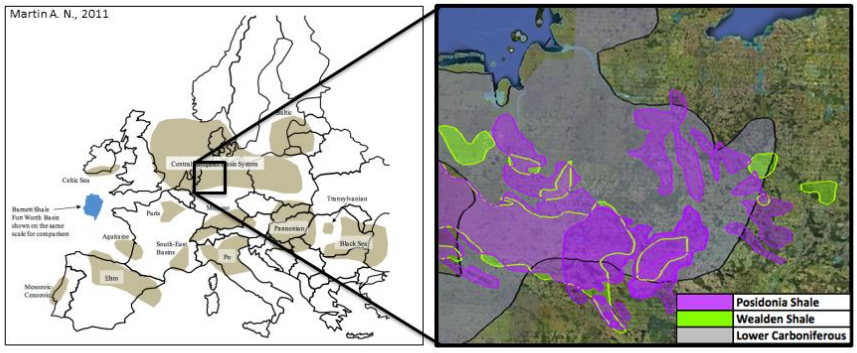


Model Parameters

- Shale formation potential
- Environmental restrictions
- Surface restrictions
- Number of wells/pads and well design
- Equipment: rigs and stimulation equipment
- Operations and logistics
- Water availability and disposal
- Production

Shale Formation Potential

- Max. vs. local extent
- Depths, thickness, fraccability, TOC, R_o



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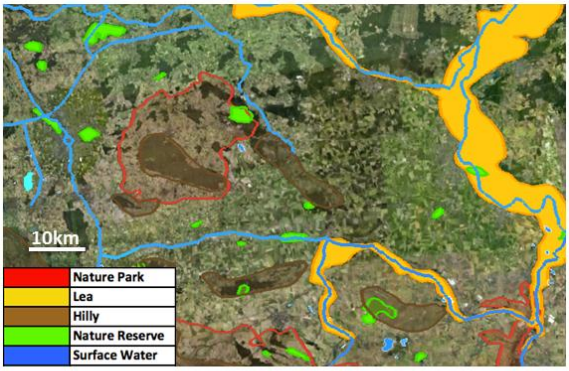
Environmental Restrictions

- National parks, surface waters, protected areas, ground water bodies…



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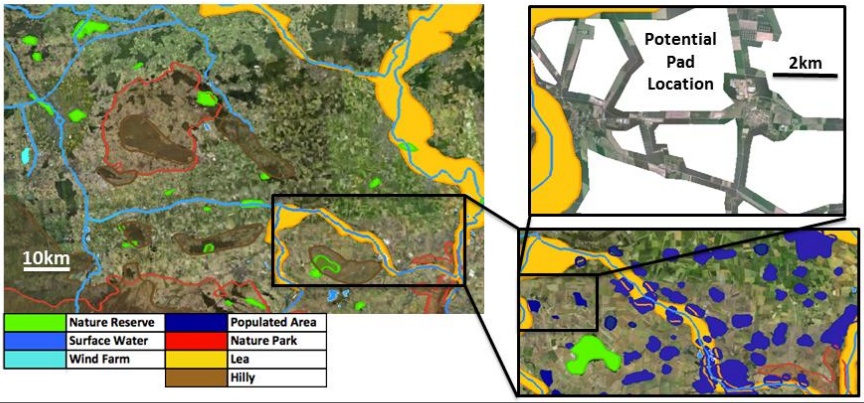
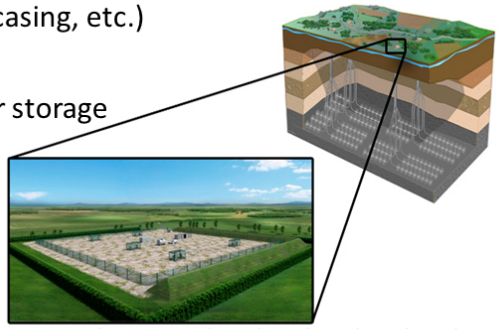
Surface Restrictions

- Surface
  - Populated areas, road network, wind parks, …



Well and Pads and Well Design

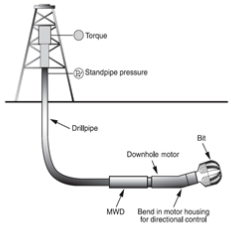
- Access roads
- Pad sizing
- Wells per pad
- Well design (trajectory, casing, etc.)
- Well spacing
- Onsite/centralized water storage
- Rejuvenation



www.millicentmedia.com

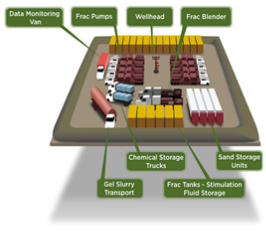
Equipment: Rigs and Stimulation Equipment

- Rig Capacity
- BHA design
- Horizontal drilling technology
- Energy requirement



Maidla, E., Slider LLC, 2009

- Stimulation equipment requirements
- Pumping power
- Water requirements
- Proppant requirements
- Stimulation job execution



www.hydraulicfracturing.com

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Pad Supply Operations

- Pad construction requirements
- Truck loads
- Identification of water sources
- Transportation routes

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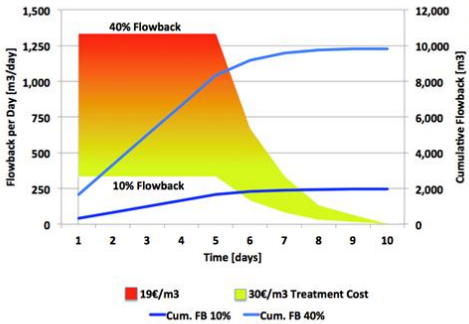
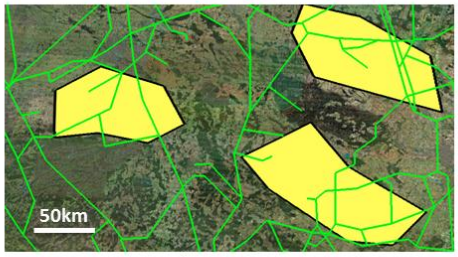
Water Treatment and Disposal

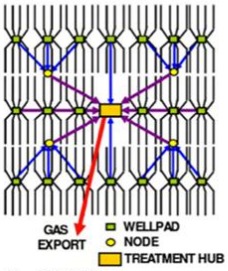
- Water disposal possibilities
- Trucking distances
- Reuse/recycling technology



Gas Transport

- Pipeline infrastructure
- Required local pipeline network

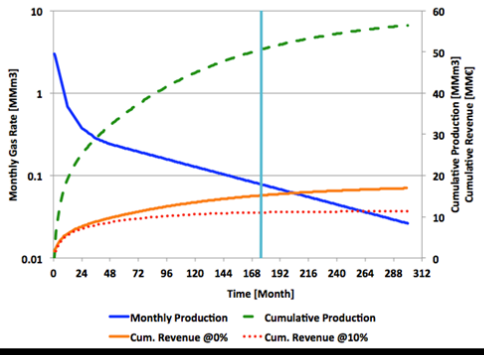




Mancini, F. 2011

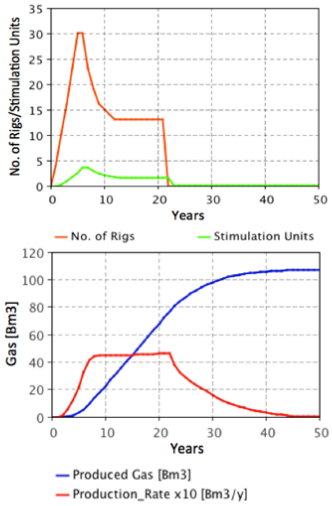
Production

- Currently US reference data used for production estimates
- Alternatively the minimum required production behavior for economical field development can be determined



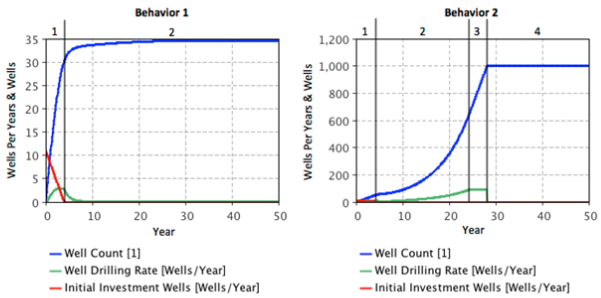
Technical Scenarios

- Rig scheduling
- Surface impact
- Water consumption
- Logistical optimization
- Local employment
- Impact on local population



Economic Scenarios

- Impact of production on available pipeline network
- Impact on gas market
- Taxation strategies for companies
- Required incentives for companies



Conclusion

- A System Dynamics Model in combination with geographic analysis was developed to study shale gas field development dynamics in specific areas
- Various scenarios and strategies can be effectively compared and optimized
- Potential regional/countrywide impacts on social life and environment can be foreseen to establish helpful countermeasures

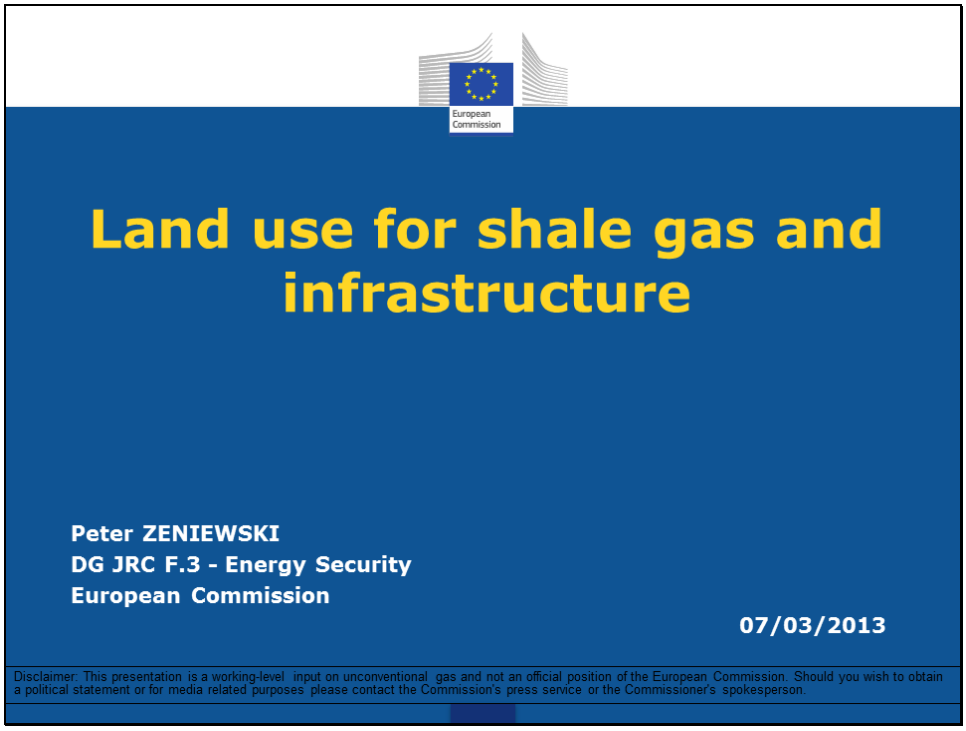
Outlook

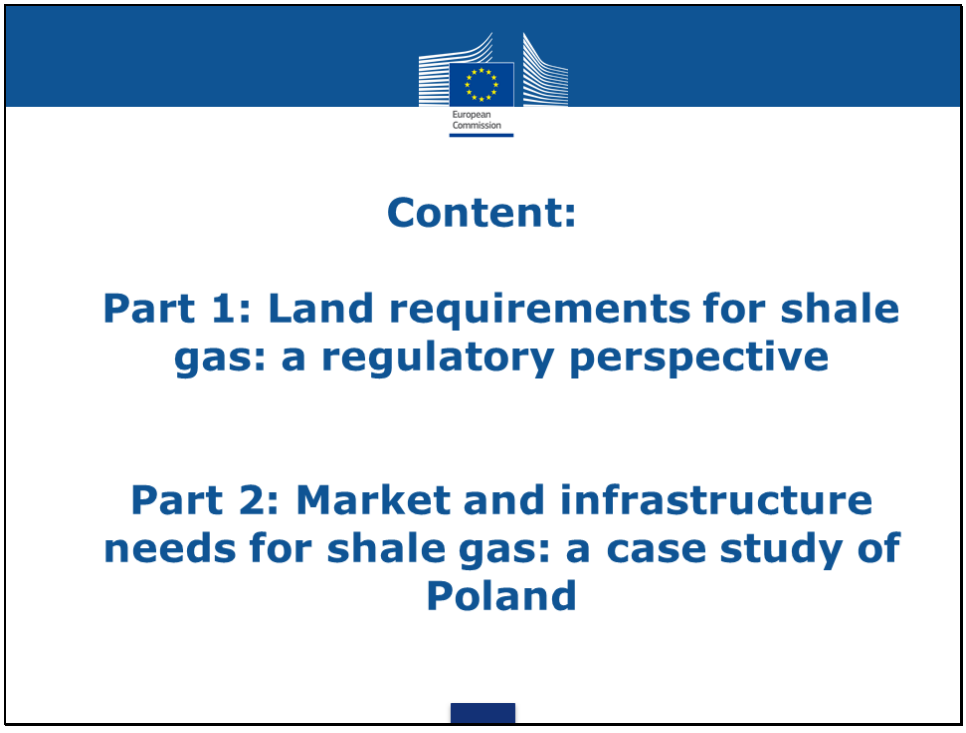
THANK YOU!
QUESTIONS?

11.10 Land use for shale gas and infrastructure

Peter ZENIEWSKI, JRC IET

11.10.1 Presentation



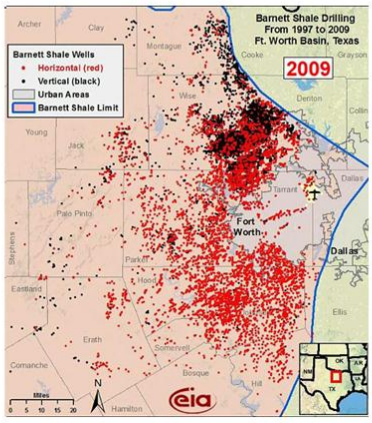


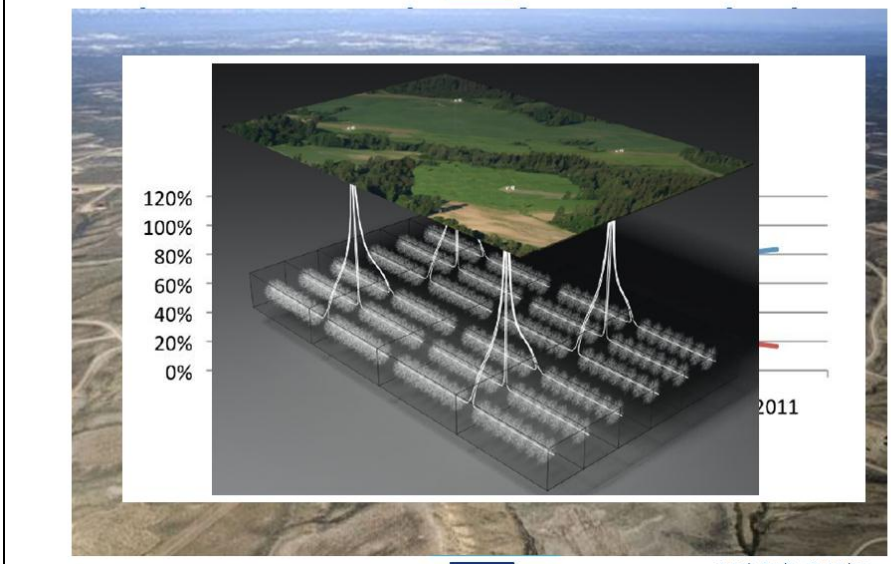
Key 'spatial' differences between US/EU

United States	Europe
Sub-surface = private	Sub-surface = state-owned
Licensing acreage = large with loose work programmes	Licensing acreage = small with strict work programmes
Industry dominated by small, entrepreneurial companies	Industry dominated by large, vertically-integrated monopolists
Permissive environmental regime	Restrictive environmental regime
Low population density	High population density
…	…

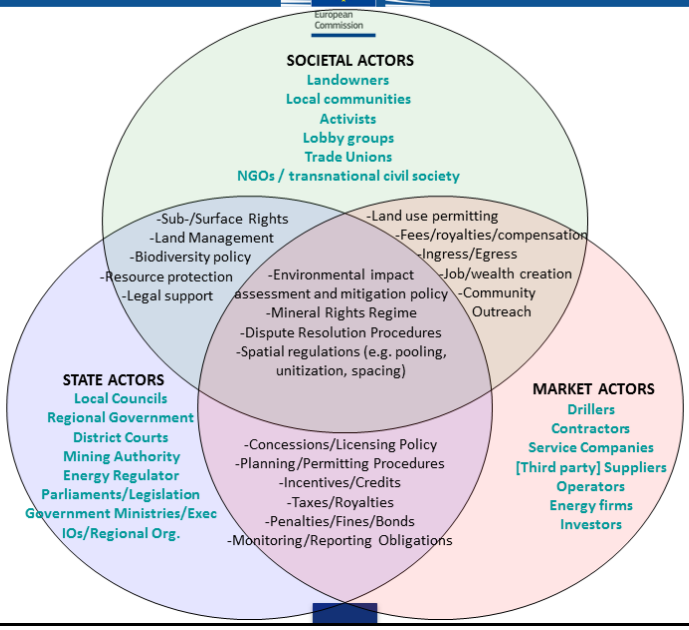
Analysts often pose the question:

"Can the conditions that enabled shale gas development in the United States be replicated in Europe?"

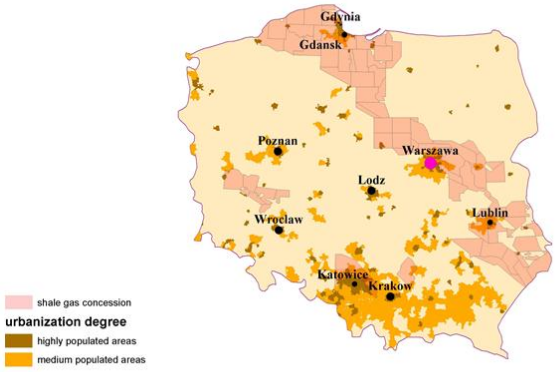




Jonah Basin, Wyoming



Part 2: Market and Infrastructure Issues
A Case Study of Poland



What if shale gas was produced today?

Question 1: Can it be transported?

Point of connection	Direction of supplies	Types of filed nominations	Total transmission capacity* [million m³/ year]	Booked transmission capacity [million m³/ year]	Not booked transmission capacity [million m³/ year]
Lasów	Poland	day/hour	1 030.5	1 030.5	0.0
Gubin	Poland	day	17.5	17.5	0.0
Branice	Poland	day	1.4	1.4	0.0
Głuchołazy	Poland	day	105.1	105.1	0.3
Drozdowicze	Poland	day/hour	5 694.0	5 694.0	0.0
Tietierowka	Poland	day/hour	196.4	188.4	8.0
Wysokoje	Poland	day/hour	5 443.8	5 443.8	0.0
Włocławek	Poland	day/hour	3 066.0	3 066.0	0.0
Lwówek	Poland	day/hour	2 365.2	2 365.2	0.0
Kamminke	Germany	day	131.4	131.4	0.0

Source: URE Report to Commission 2011

What if shale gas was produced today?

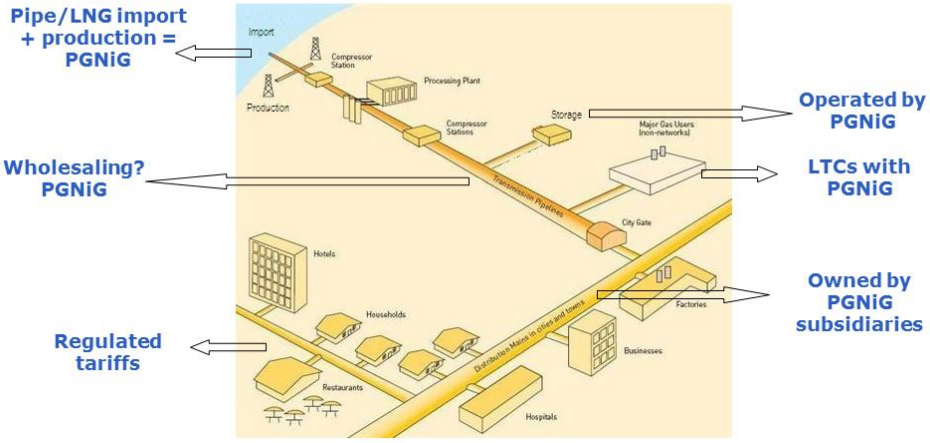
Question 2: Can it be transported?

The only internal entry points overlapping shale plays are at Tarnow

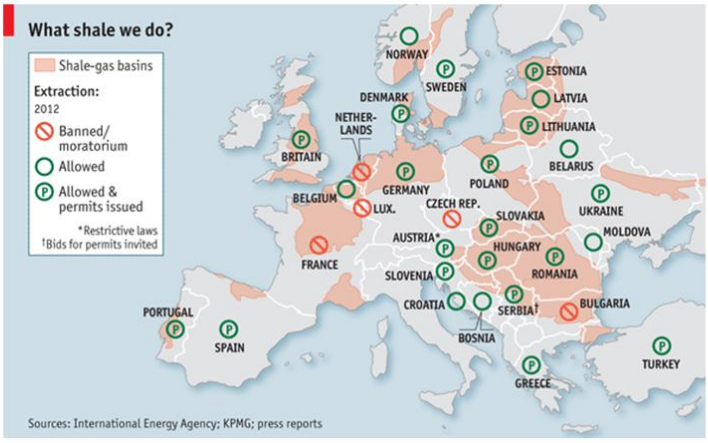
Kaliski et al 2011

What if shale gas was produced today?

Question 2: Who would buy it?



State of play in Europe



Institute for Energy and Transport

European Commission | Joint Research Centre | F03 - Energy Security Unit

Phone: +31 22456 5406

Peter.ZENIEWSKI@ec.europa.eu

11.11 Accelerating the economic appraisal and development of European shale liquids - possible R&D pathways

Ruud WEIJERMARS, TU Delft

11.11.1 Presentation

Accelerating the economic appraisal and development of European shale liquids – possible R&D pathways

Ruud Weijermars [1,2]

1. Alboran Energy Strategy Consultants, Senior Consultant

2. TU Delft, Director Unconventional Gas Research Program (UGRI)

JRC/IET E&I Workshop
Amsterdam, the Netherlands
7-8 March 2013

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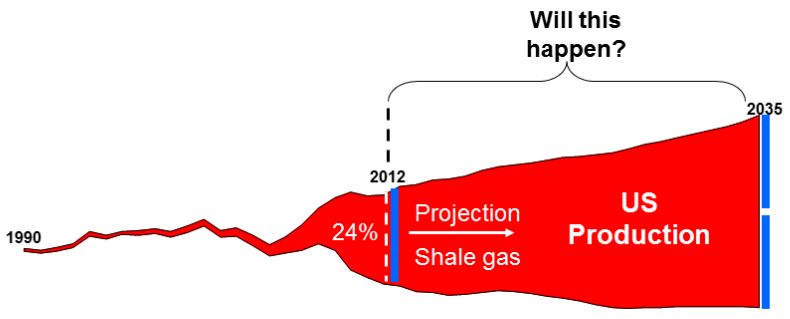
Big Questions for Europe

Will US become a net exporter of LNG starting in 2016?



Alas.....strong signals of US shale gas fatigue

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Ruud Weijermars – Brief Background

Expertise & Research Focus:

- Petroleum Economics & Energy Strategy
- Geomechanics & Wellbore Stability Modelling

Affiliations: Alboran.com

Senior Consultant, Alboran Energy Strategy Consultants

Director of UGRI, Delft University of Technology (NL)

Research Associate, AGL Salt Tectonics, BEG UT Austin (US)

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1. US shale gas explosive growth has turned rest of the world on!

1. Is the US domestic shale gas supply secure?
2. Can we bank on LNG exports coming from the US to Europe?
3. What if the global shale gas optimism and high hopes turn into a cold turkey experience for gas consumers?

What must Europe do?

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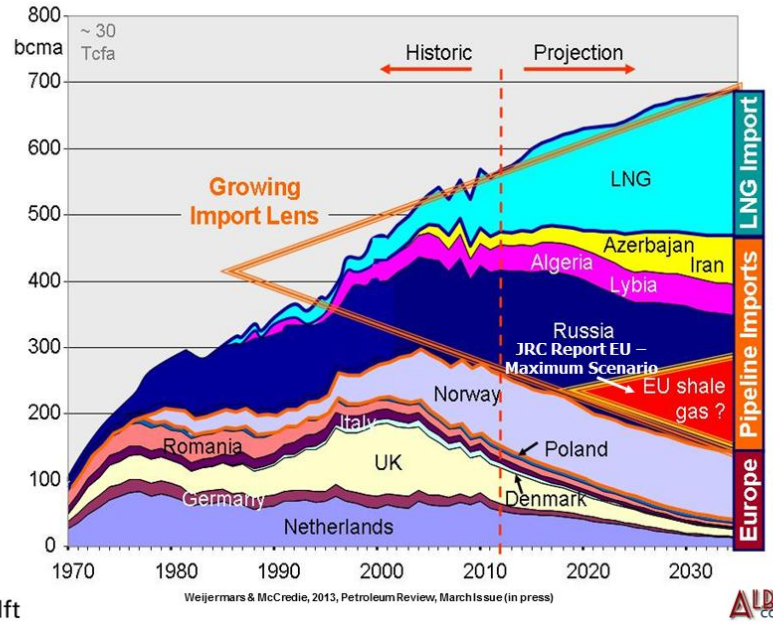
2. Make EU shale development a priority



Weijermars & McCredie, 2013, Petroleum Review, March Issue (in press)

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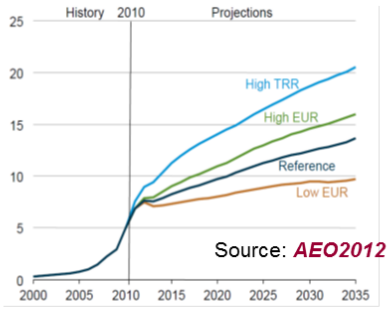
3. Model European Gas Markets

- US gas production was assumed secure and rising in NEMS…
- But were/are these projections reliable? How reliable?
- NEMS projections on the gas price in the past 25 years:

- correct for 4 years
- Way too high for 18 years
- way too low for 3 years

US Gas Output Forecast based on NEMS



Source: *AEO2012*

Conclusion:

There is strong driver for energy security bias in the US NEMS: call it focusing illusion and affective forecasting!

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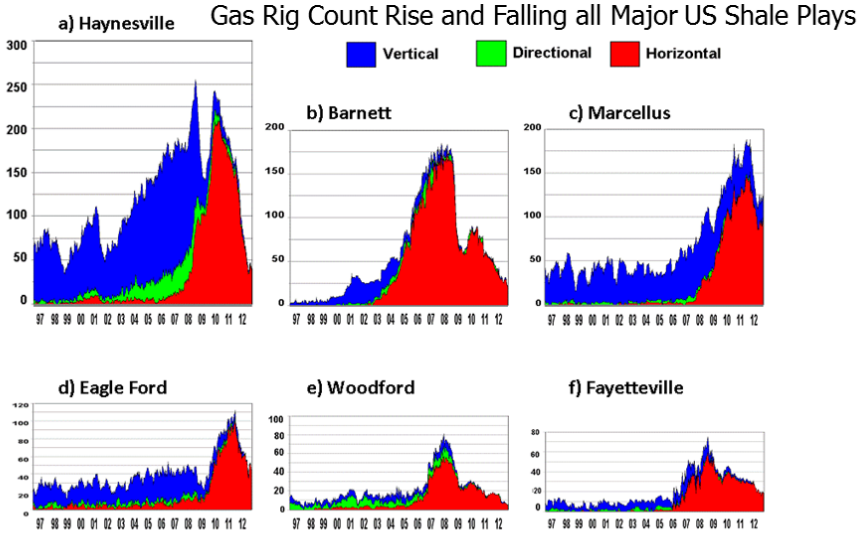
4. Model European Gas Markets <u>without</u> affective forecasting

Gas Rig Count Rise and Falling all Major US Shale Plays



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Weijermars, 2013 (in review; using statistics of Baker Hughes and WTRG Economics).

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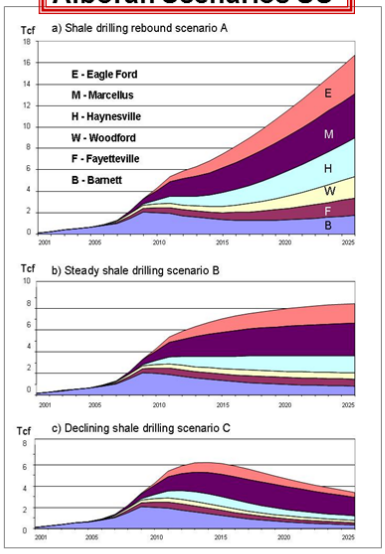
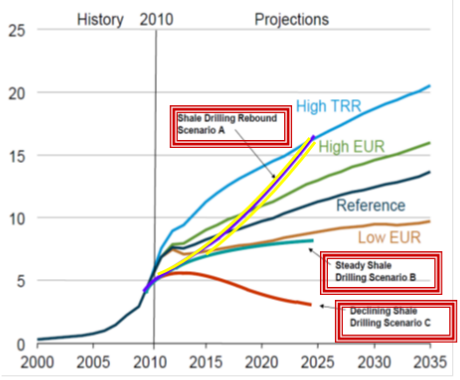
5. Develop realistic drilling scenarios

Alboran Scenarios US



Weijermars, 2013 (in review).

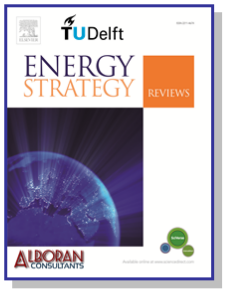
NEMS <u>lowest</u> EUR case requires a steady drilling program



<u>Conclusion:</u>

Declining shale gas drilling rate is not taken into account by NEMS (or not yet – remember - 2 year delay in models).

6. Importance of Energy System Models



Editor-in-Chief:

Ruud Weijermars

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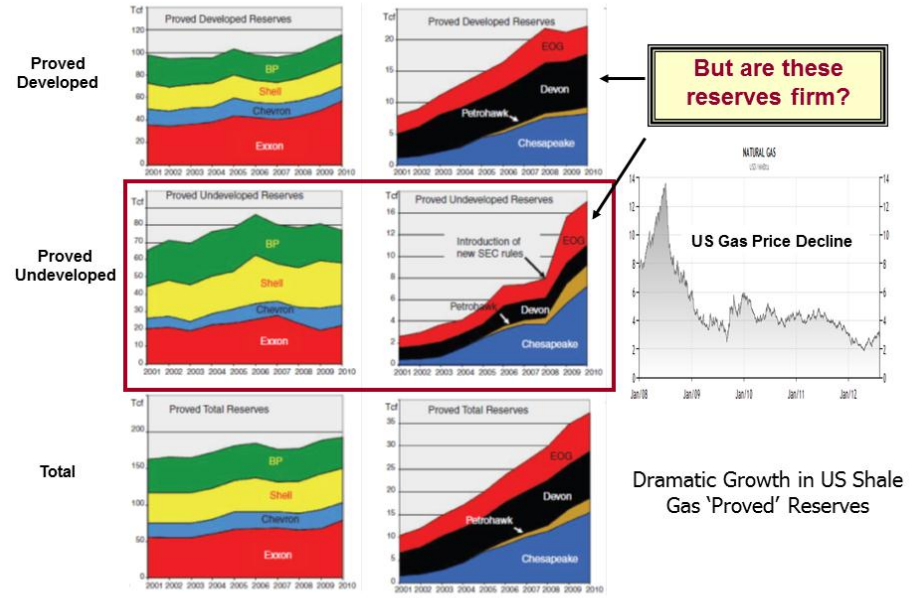
Energy Strategy Reviews

- Platform for leading energy system modellers.
- Peer-reviewed articles on energy system models.
- Includes strategy, planning, decision making, and analysis related to society's energy needs.
- Stimulates the exchange and sharing of knowledge and best practice.

- The **impact of economic realities of** US shale gas potential **has been neglected** as highlighted in a critical review by Brooks, 2012.

Recent Charter for Energy Strategy Research (Weijermars et al., 2013) emphasized:
- ESR seeks to **alert for national energy strategies that facilitate choices or bias based on populist demand or special interest groups**.

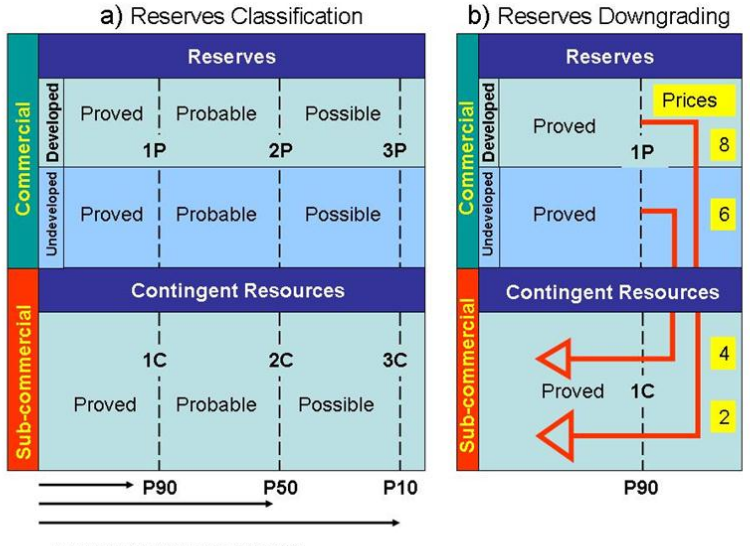
7. Governance Directives: Reserve Reporting Rules



Dramatic Growth in US Shale Gas 'Proved' Reserves

Weijermars 2012 (SPE 1160927- PA)

8. Impending Impairment of US Shale Reserves



Weijermars 2013, First Break, vol. 31(1), p. 39-48.

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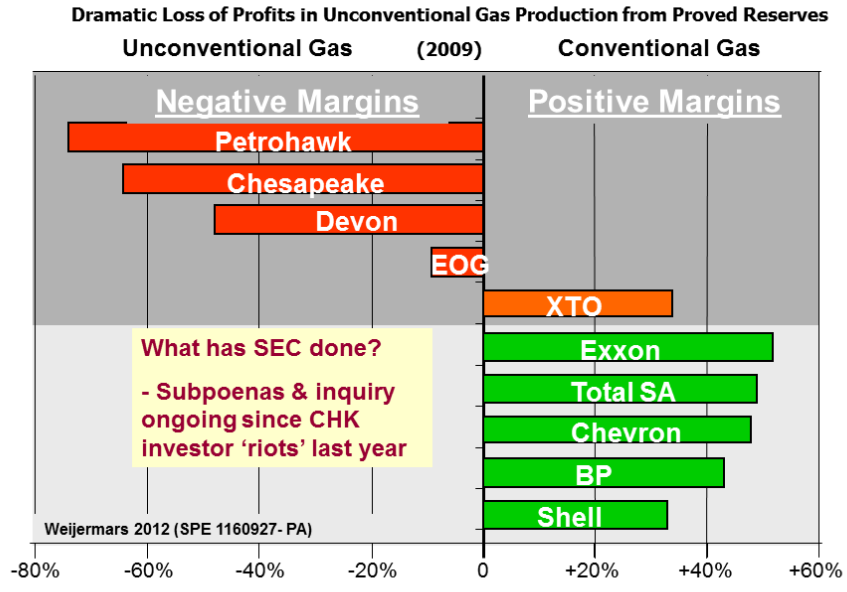
9. Impairment of US Shale Reserves Overdue!!



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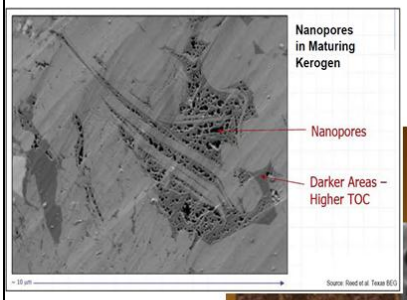
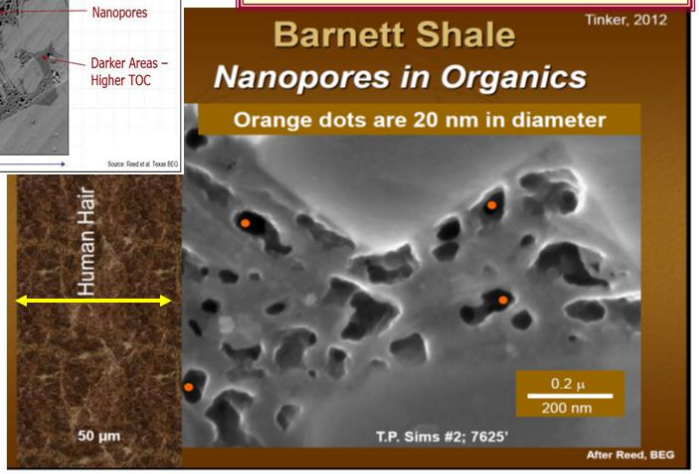
10. The Prize is real - a hydrocarbon nanoPrize



Fracking needed

But first make sure you have organic maturity windows mapped out right



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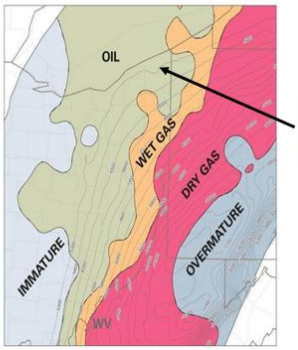
11. Move to the liquid-rich areas

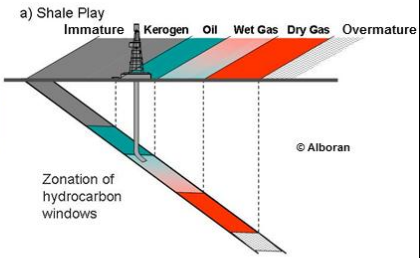


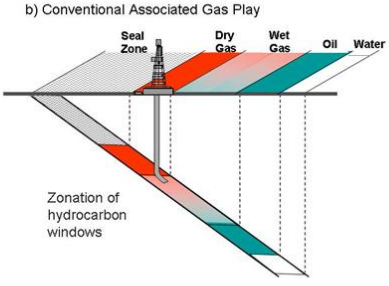
Higher Mmbtu value per Mcf

	$/Gallon	$/Barrel	Average Component Mix	Average Price per Barrel of Natural Gas Liquids
Ethane	$0.36	$15.12	42.5%	$6.43
Propane	$0.80	$33.60	27.5%	$9.24
Isobutane	$1.46	$61.32	10.0%	$6.13
Normal Butane	$1.38	$57.96	7.5%	$4.35
Natural Gasoline	$1.80	$75.60	12.5%	$9.45
Total				$35.60

	$/MMBtu	$/Barrel
Natural Gas	$2.45	$14.70

NGL-Natural Gas Price Spread $20.90





- Weijermars et al. 2013, in review

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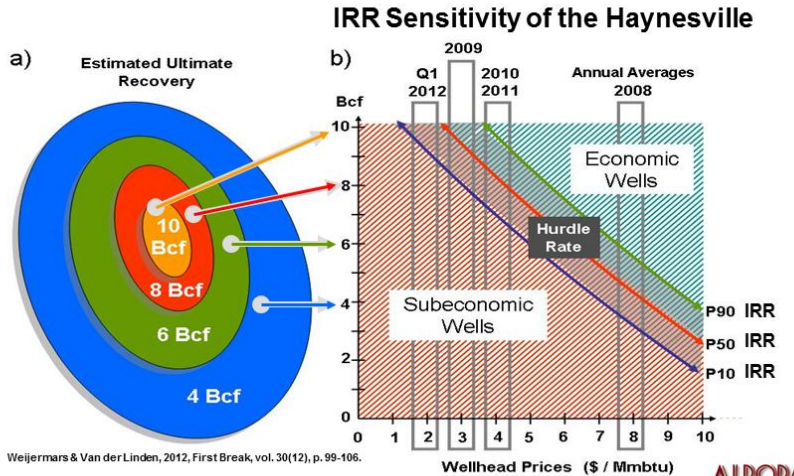
12. Delineate Sweet Spots

Plot accounts for sensitivity to:
- Regional variations in well productivity
- Volatility in gas wellhead prices



Weijermars & Van der Linden, 2012, First Break, vol. 30(12), p. 99-106.

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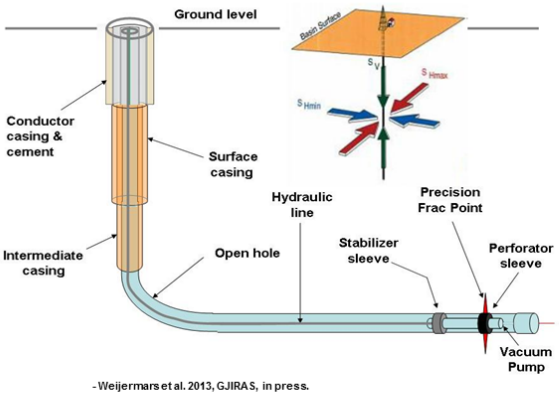
13. Manage your Stress: Precision Fracking Device

Invest in **fracking technology** that can make your operations economically robust



- Weijermars et al. 2013, GJIRAS, in press.

- Innovative device to better control the Frack number
- Alboran holds provisional patent for concise frack number algorithms
- Contact us if you are interested!

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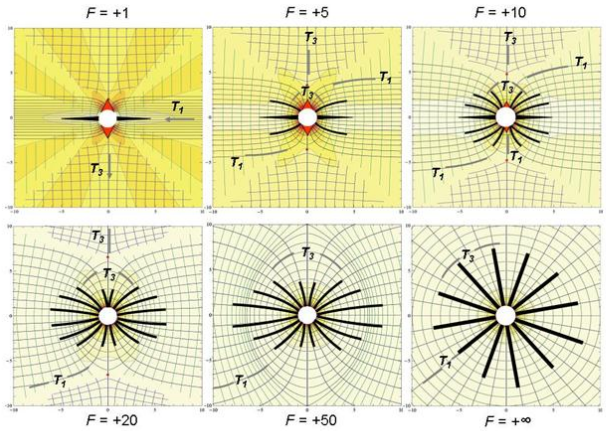
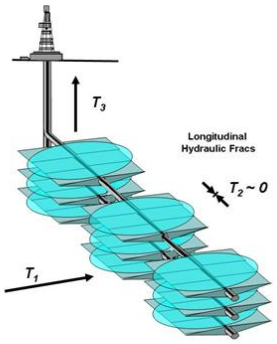
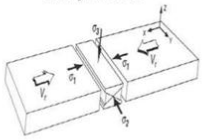
14. Work with the regional stress field





Tectonic Compression



Weijermars & Schultz-Ela 2012 (SPE 152559)

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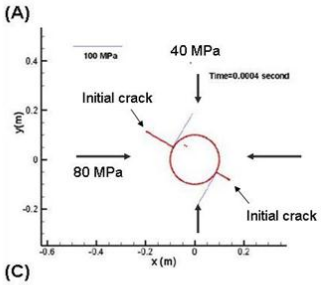
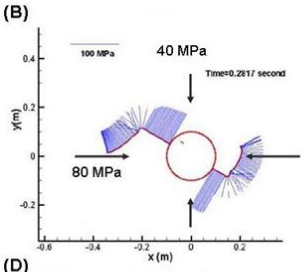
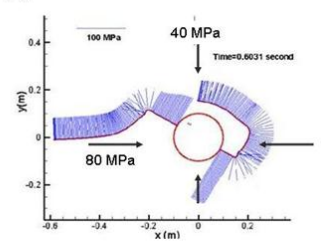
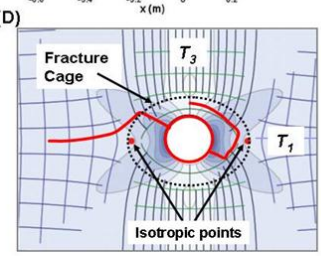
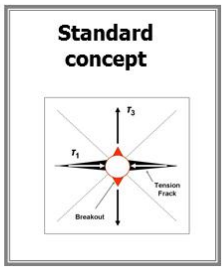
15. Avoid Fracture Caging











This may happen

- Weijermars et al. 2012, First Break, vol. 30(1), p. 35-36;
- Weijermars et al. 2013, GJIRAS, in press.

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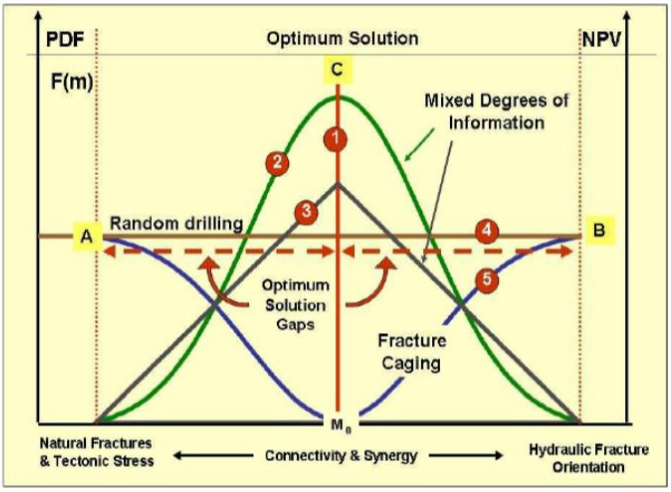
16. Connect to the natural fractures



Weijermars & Schultz-Ela 2012 (SPE 152559)

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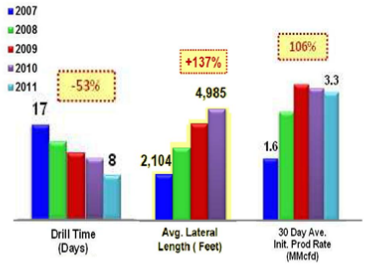
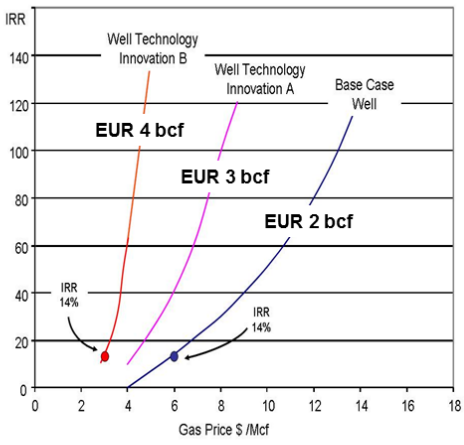
17. Foster improved technology: Sensitivity analysis of IRR to well technology innovation

- Well technology B doubles EUR over the base case.
- IRR of 14% can with lowered gas price of $3/Mcf be reaize with Technology B.
- Base case well technology can only match this if the gas price is twice as high ($6/Mcf).



Source: Southwestern Energy

Evaluated for Barnett Type of Geology



Alboran study 2013

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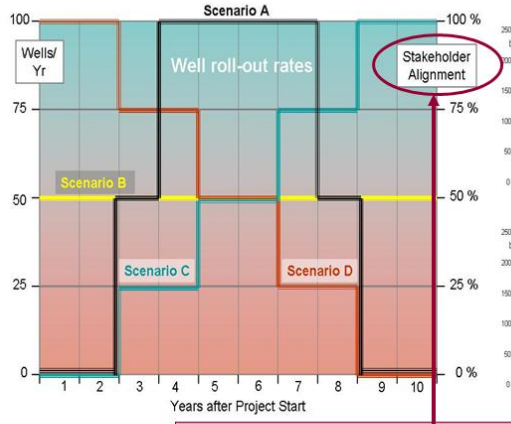
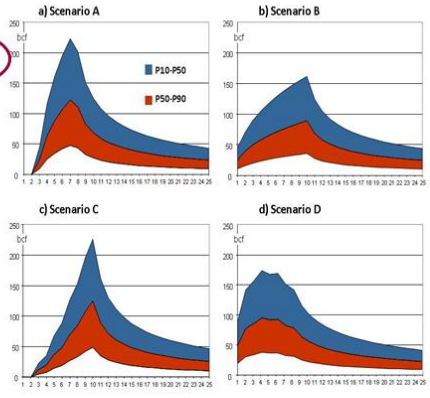
18. Optimize well-roll-out scenarios

All scenarios realize 100 wells over 10 years time

Annual production profiles are all different for the 25 year lifecycle





Choice of scenario may be affected by stakeholder alignment process

Weijermars 2013, First Break, vol. 31(1), p. 39-48.

Produced with *Alboran DCF Shale Scenario Builder™*

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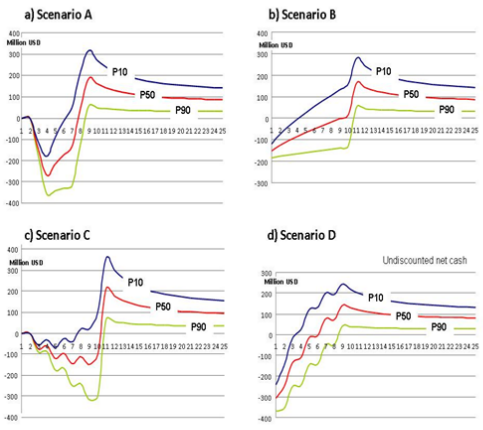
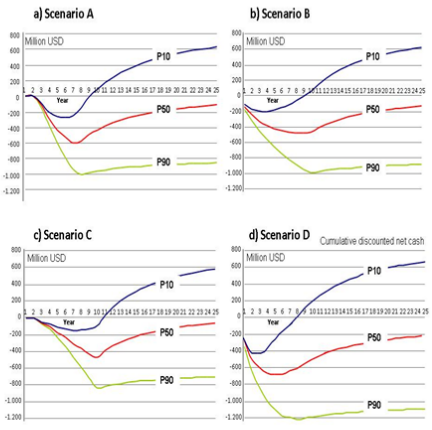
19. Use NPV and IRR uncertainty ranges

Undiscounted Annual Net Cash



Example for a fixed gas price $6/Mcf

Cumulative discounted Net Cash Flow



Weijermars 2013, First Break, vol. 31(1), p. 39-48.

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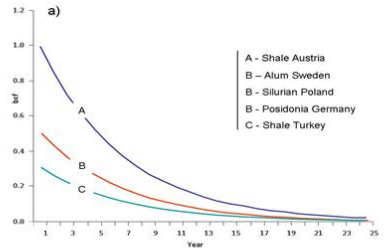
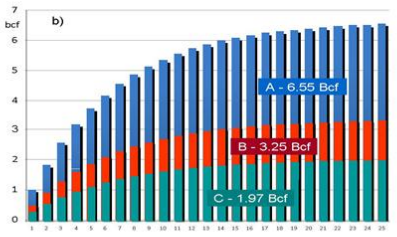
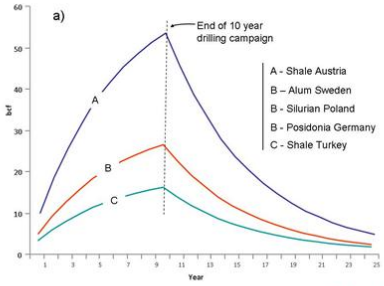
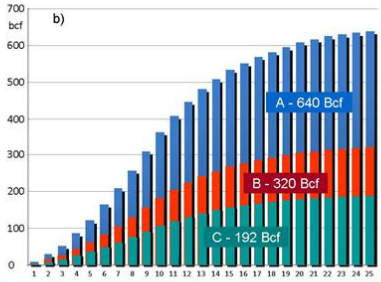
20. Model European shale gas production potential and economics





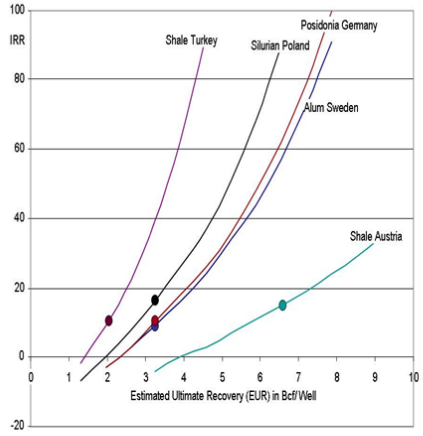




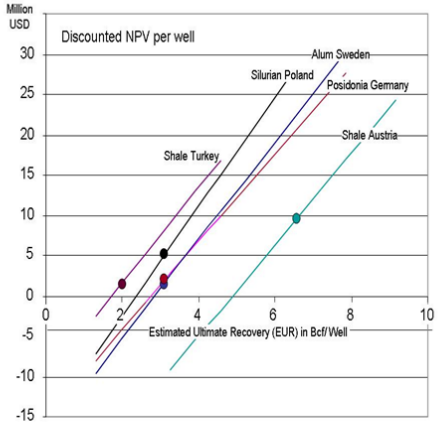
TUDelft Weijermars 2013, Applied Energy vol. 106, p. 100-115. Produced with *Alboran DCF Shale Scenario Builder™* ALBORAN CONSULTANTS

22. Model sensitivity to EUR variations

(a)



(b)



Weijermars 2013, Applied Energy vol. 106, p. 100-115.

Produced with *Alboran DCF Shale Scenario Builder™*

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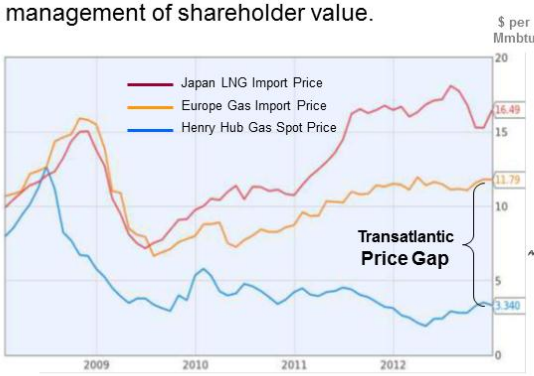
23. Jump past US Shale Carrot & Stick ordeal

- **CARROT** – shale operators hailed to develop shale gas. This has boosted US "apparent energy security" and lowered US energy prices (gas and gas for the Electrical Power stations – subsidizing electricity bills).
- **STICK** – Investors need to discipline shale operators into due diligence in reserve reporting and prudent management of shareholder value.



What can operators do?

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Main Conclusion: Develop Expertise in Europe

TU Delft

- Applied Research, Lab driven
- PhD funding model
- 4 year programs
- Development of shale well reservoir model – using individual frac stage fluxes to aggregate well productivity.

http://ugri.tudelft.nl/

Alboran

- Proprietary shale technology services
- Consultancy rates
- Fast track R&D
- *DCF Shale Scenario Builder™*
- *Smart Frack™ precision fracking algorithms*

http://alboran.com

For research options talk to me!

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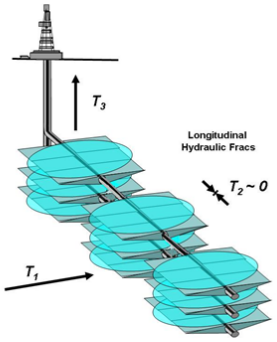
Practical Conclusions

Fracking Choices:

1. Work with the regional stress field
2. Know the regional stress field
3. Avoid fracture caging
4. Select your best producer well architecture
5. Connect to the natural fractures
6. Foster improved technology
7. Aim for precision fracking and stress management



Weijermars & Schultz-Ela 2012 (SPE 152559)

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Possible actions (slide 1 of 2)

- **Appoint an EU Shale Resource Ambassador**
  - Promote societal legitimacy shale resources
  - Main driver should be energy security (shale resources do not make much money!)
- **Regulate Governance Issues**
  - Allocation regional benefits & dealing with public (communication)
  - Reserves reporting guidelines + research access
  - Operational monitoring issues + research access
  - Environmental issues (e.g.: drinking water protection zones)
  - Development of standards & sharing of best practices on risk mmt
- **Model the regional & energy system for gas & oil price elasticity**
  - Prevent US style price collapse (pipeline capacity shortage & overproduction)

Possible actions (slide 2)

- **Map out Geoscience & Petrophysics (European database)**
  - Maturity windows for all major shale plays
  - Regional in-situ stress maps
  - Seismic risk zones
  - Identify prime shale development regions (based on above plus surface conditions: markets, pipelines, natura 2000 and local support levels)

- **Improve engineering practices & tools**
  - Stimulate well technology innovation (pilot projects)
  - Improve fracking efficiency & feedback loop
  - Boost well productivity by intelligent stimulation

- **Improve economic models & tools**
  - Realistic field development scenarios (infrastructure)
  - Well rollout rate & architecture
  - Optimize return on investment

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11.12 IRGC draft risk governance guidelines

Marie-Valentine FLORIN, IRGC

11.12.1 Abstract

The International Risk Governance Council is currently doing project work to develop "risk governance guideline for unconventional gas development" that would have relevance for various countries and context situations. These guidelines, elaborated after comprehensive literature review, interviews with experts, and a multi-stakeholder workshop held on 5-6 November 2012, will aim to address opportunities and risks for policymakers, regulators and industry. In addition to the need to mitigate the technical, environmental, social and economic risks involved in the industrial process, IRGC reminds of the importance to involve and communicate with stakeholders and in particular local communities, and to acquire political legitimacy.

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11.12.2 Presentation

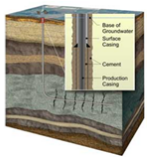
IRGC project: developing risk governance guidelines for unconventional gas development

- *That have relevance for various countries and context situations*
- *Elaborated after comprehensive literature review, interviews with experts, and a multi-stakeholder workshop on 5-6 November 2012*

→ What are the elements that need to be included in generic guidelines addressing policymakers, regulators and industry

- Evaluate the opportunities and benefits
- Address the (potential) risks seriously – don't underestimate them ("otherwise the public will find them")
- Develop appropriate regulatory frameworks
- Be explicit and transparent about objectives - communicate

What are the main components of a complete risk analysis?



- Technical & environmental risks need to be identified, assessed and managed, including*:
  - Water management (quality and quantity)
  - Air emission control (GHGs and local air pollutants…)
  - Induced seismicity (for ex. in the UK)
  - Ecosystems and land-use impacts
- Economic, social and political risks need to be identified, assessed and managed*
  - Community development risks (for local populations)
  - Financial & economic risks (for industry)
  - Political risks (for elected authorities)
- Perceived risks need to be addressed*
  - Even if scientists, industry, regulators or policy makers believe they are not relevant
  - Inadequate risk perception can derail even the best technical plans

*but not limited to – this presentation focuses in particular on overarching risk governance – However, IRGC emphasises the need to address very seriously the environmental risks related to hydraulic fracturing.

The following three slides address specific issues that are faced by:

1. policy makers
2. regulators
3. industry

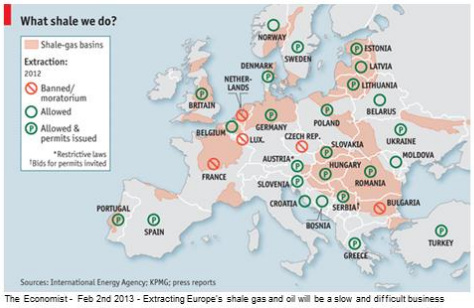
1. Getting political and social legitimacy

- The challenge for political officials around the world is to determine whether development of an UG industry is in the interests of their constituents and, if so, what type of risk-governance system should be instituted.
- The success of UGD will not be determined solely by technical and economic factors. Unless UGD is perceived to be legitimate by political officials and their constituents, UGD will not be sustainable.
- Social legitimacy is necessary in order to gain political legitimacy.
- Policymakers need to understand the various policy challenges and trade-offs involved, and address them openly

IRGC suggests the following guidelines for acquiring political and social legitimacy:

- Investments in related infrastructure
- Systematic and sustained commitment to the necessary capabilities
- Community engagement
- Strong and trusted regulatory system
- Building on the principles of sound science and data verification
- Cooperative efforts between countries
- etc

2. Developing robust regulatory frameworks



The Economist - Feb 2nd 2013 - Extracting Europe's shale gas and oil will be a slow and difficult business

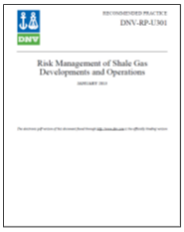
Including:

- Learning from existing regulatory frameworks, industry good practices and each other
- Assignment of regulatory authority and responsibility
- Pre-drilling planning and ongoing monitoring
- Technical standards
- Regulatory mechanisms: use of permitting, enforcement, and voluntary practices
- Public assurance and participation
- Financial viability

3. Strengthening responsibility and a safety culture in industry

- Collecting and sharing data
- Dealing with technical failures, as well as human & organisational failures
- Considering reputation, social licence to operate
- Working with others to share good practices
- Examples of how other industries have organised to meet these objectives ….
- Need to establish standards? Certification?

"Baker report" 2007



Overarching risk governance recommendations / guidelines

(work in progress)

- Assessing regional and national energy needs and demands
- Community and stakeholder participation
- Addressing land-use change and planning
- Choosing the appropriate technology
- Doing complete life-cycle assessments
- Mitigating technical and environmental risks
- Developing and implementing an appropriate regulatory framework
- Establishing baseline monitoring requirements
- Strengthening a responsibility and safety culture
- Establishing performance standards and mandates
- Considering liability issues
- Developing international collaboration

Conclusion: key themes for risk governance of unconventional gas developments

- There are some cross-cutting issues that all stakeholders should consider: **communication, transparency and trust**
- **Community and stakeholder participation** matters and require guidelines for engaging with stakeholders, as well as illustration of good practices (ExxonMobil, OECD guidelines, Seweso directives, Polish experience, etc
- **International collaboration** is needed, for the sharing of good practices, for capacity building for knowledge transfer and because of geopolitical considerations
- The development of **voluntary schemes or standards** to deal with major environmental and social issues would certainly be welcome, to reassure the public and create confidence and trust.
- **A voluntary platform for sharing and disclosing information between industry and with regulators and scientists would probably help collaboration and build trust.**


international risk
governance council
Thank you
@ EPFL, CM 1-517, 1015 Lausanne, Switzerland | tel +41 (0)21 693 8290 | www.irgc.org
© international risk governance council
EC- JRC - E&I workshop Safe and Efficient Shale Gas Exploration and Production, Amsterdam 7 March 2013

11.13 DNV Recommended Practice on Risk Management

Lars SØRUM, DNV

11.13.1 Abstract

Although several stakeholders have developed documents and guidelines covering parts shale gas activities, a complete risk management framework is lacking. A globally acknowledged framework would Increase stakeholder confidence in the shale gas operators' ability to conduct their business safely and sustainably. As the shale gas industry is at the centre of political debates across Europe, the public and academic opinions are polarised. The industry can gain stakeholder acceptance by implementing operational best practices and demonstrating that shale gas development and production activities can be executed in a safe and responsible manner. In addition to mitigating the technical and operational risks the benefit of independent verification is evident – it mitigates the significant non-technical risks resulting from a lack of public trust and understanding of shale gas extraction. This paper will focus on how the identification and mitigation of identified risks within a risk management framework ensures safe and sustainable operations; it will highlight the most prominent risk areas and discuss the need to understand and manage "total risk picture", both "actual risk" and "perceived risk". The paper outlines how the use of recommended practices of shale gas operations can mitigate technical and non/technical risks and the associated stakeholder concern. The paper will also discuss available peer reviewed research and the need for such work.

Presentation summary
The presentation will aim to provide understanding of how managing the risk picture of shale gas operations by applying risk management frameworks supported by independent verification will provide a "social licence to operate".
The presentation will address the use of recommended practices and includes a summary of DNV's recommended practice in a life cycle perspective including a discussion on baseline surveys. The presentation will then show how the operator can manage their total risk picture by discussing different types of risk and risk management frameworks. The presentation will include examples of risk, risk pictures related to three prominent risk areas; contamination of ground water, emissions to air and induced seismicity by hydraulic fracturing to demonstrate how the operator needs to manage both "actual and perceived" risks.

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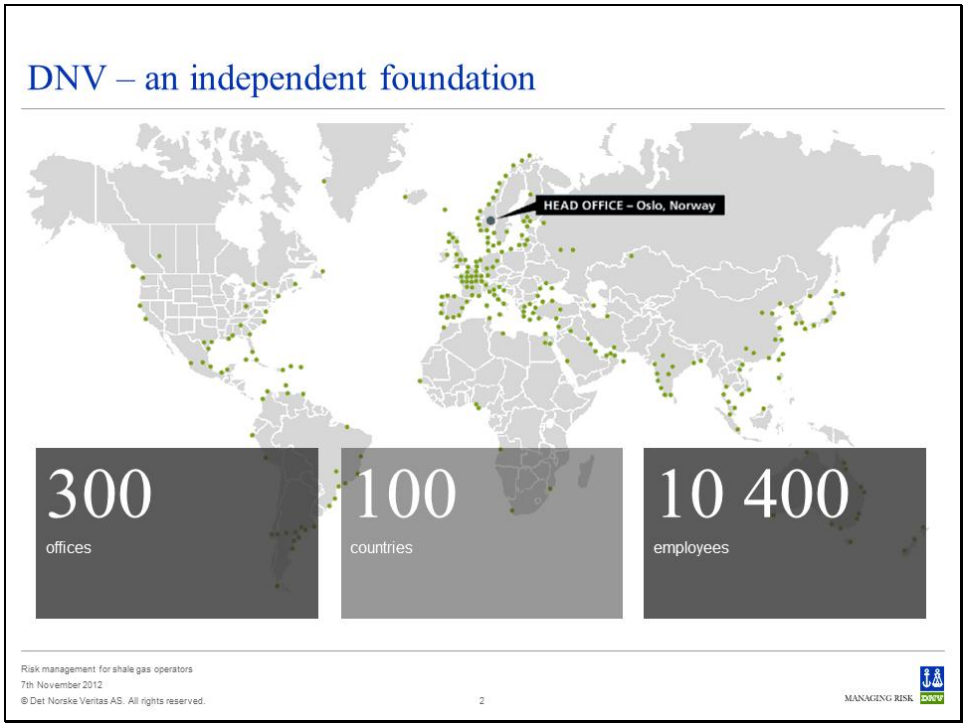
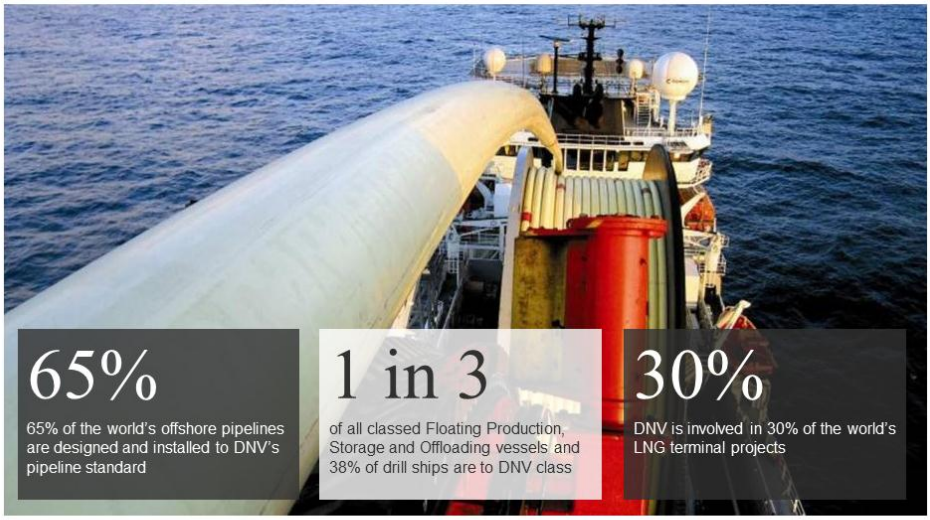
11.13.2 Presentation

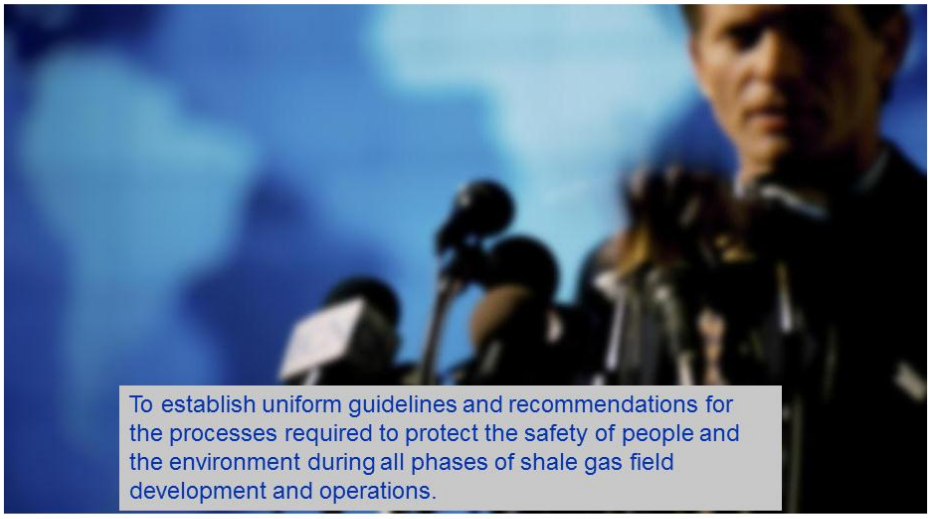


DNV has supported the entire value chain for natural gas since the late 60s and has an expert role in the oil and gas industry



Recommended Practice (RP) for Shale Gas Operators

DNV has recently published a RP through stakeholder consultations with the industry and regulators



To establish uniform guidelines and recommendations for the processes required to protect the safety of people and the environment during all phases of shale gas field development and operations.

The Recommended Practice addresses all aspects of shale gas operations in a life cycle perspective

- Management systems
- Safety, health, and the environment
- Well integrity
- Management of waste, resources, water and energy
- Infrastructure and logistics
- Public engagement
- Stakeholder communication
- Permits

DNV advises to carry out extensive baseline surveys

Your "risk environment"

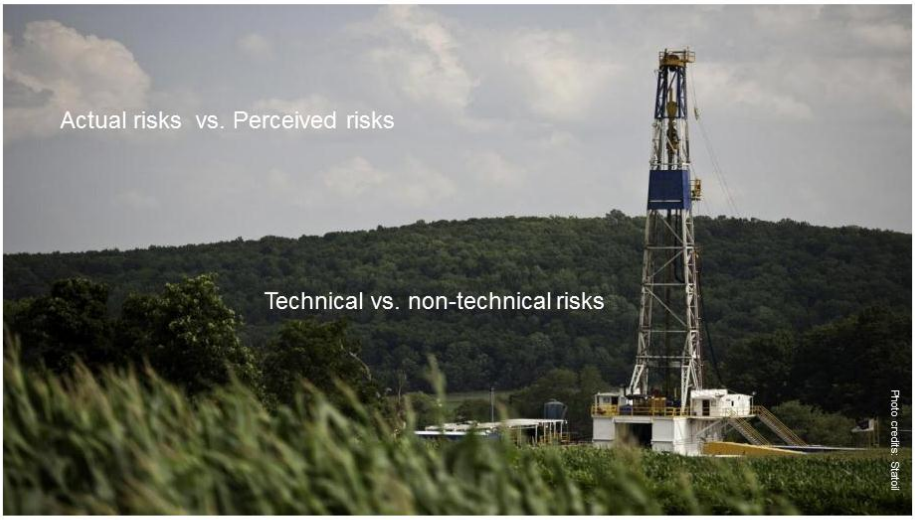
What is Risk?

- Assessing risk requires consideration of the combination of likelihood (probability) and consequence (impact)
- The first step in any risk assessment process is to identify the hazards, then determine the likelihood and consequence of such hazards
- The process of identifying the potential risks to your asset must be thorough
- If you do not identify potential risks, you cannot manage them effectively
- There are different types of risks; financial risks, safety risks, health risks, environmental risks, public/welfare and goodwill risks (perceived and value based)

There are financial risks to be managed

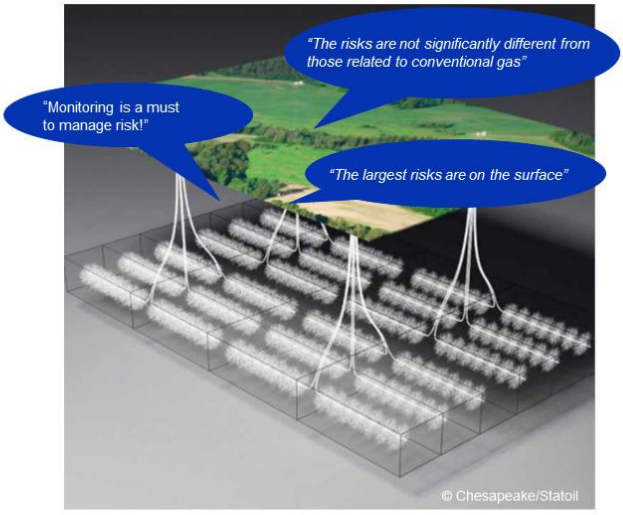
- "You do not know what you have before you drill!" wet and dry plays
- Economical extraction ratios unknown?
- Large investments – cost of waiting?
- Lack of economies of scale in Europe?
- Lack of suppliers and infrastructure?
- Well pad construction and development costs?
- Gas price divergence?

The shale gas industry is at the centre of political debates across Europe and public and academic opinions are polarized – this creates complex risk environments



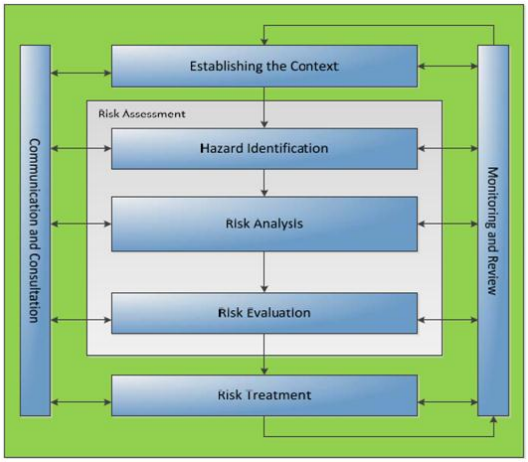
The risks for shale gas operators are largely non-technical, on the surface and often public welfare and goodwill risks

- Public and political acceptance
- Water and chemicals management
- Technology, competence, knowledge not fully applied
- Wastes and spills, including those from fluid hydrocarbons
- Impact on local community and use of land



Address your "total risk picture"

Apply robust risk management principles



Establish trust, credibility and stakeholder confidence through independent verification

To maintain "Social licence to operate" alleviate public and stakeholder concerns consider risk management activities for all relevant project and pad life cycle phases

Exploration and appraisal
- Public Engagement Services and Risk Workshop Facilitation
- Risk Identification and Ranking and Permitting Support
- Management Systems Gap Analysis and Risk Management Framework Development
- Initial Environmental Base Line Surveys and Verification Services

Pad Plan and design
- Risk Barrier Management and Safety/Environmental Critical Elements Identification
- Assessing Management Systems and Risk Management Frameworks
- Well Systems Design and Drilling Procedures Verification
- Environmental Impact Assessments

(Pad) Construction
- On Site Inspection and Supervision
- Manufacturing Verification
- Supply Chain Risk Assessments
- Water Resources and Energy Management Analyses

Pad operations
- Waste and Wastewater Management
- Full Environmental Base Line Survey Verification
- Verification of Management Systems; Procedures; Plans; Critical Equipment and Infrastructure
- A Periodical Inspection and Verification Scheme to Monitor Consistent Compliance

(Well/Pad) Abandonment
- Decommissioning Verification
- Site Remediation
- Post Closure Monitoring and Verification
- Post Closure Environmental Impact Analysis

Summing up

Shale gas extraction, as with most human endeavours is not risk free

Shale gas operations can be done safely and sustainably using best practices and appropriate risk management

DNV's position is that operators need to safeguard their business by applying risk management principles and benefitting from independent oversight

Use recommended practices to ensure safe and sustainable operations

Address your total risk picture to maintain "licence to drill!"

Safeguarding life, property and the environment

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www.dnv.com

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11.14 Shale resources: assessing practices and risk, and environmental and social considerations

Paul KRISHNA, XTO Energy

11.14.1 Abstract

The safe and efficient development of shale oil and gas resources depends on two important elements. First, a company should demonstrate a responsible operations philosophy and second, it should have an established and effective risk management approach or framework. All businesses have risks. In the case of shale oil and gas, it is important to identify the risks, assess the risk based on real data, and mitigate the risk if significant to lower levels. Risks should be assessed and managed by the probability and consequence rather than as absolute worst case scenarios. A number of peer reviewed technical studies exist that enable companies to apply this risk management framework to water management, groundwater protection/well integrity, air quality and emissions, induced seismicity, and social and community concerns. This risk management framework is presented as a responsible approach for progressing shale development.

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11.14.2 Presentation

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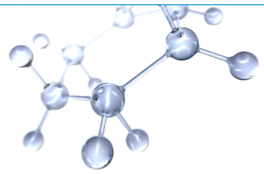


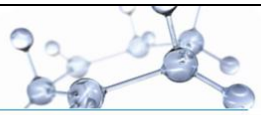
Shale Resources: Assessing Practices and Risk, and Environmental & Social Considerations

Paul P. Krishna, Manager - Environmental, Health & Safety Issues
ExxonMobil XTO Energy

March 7, 2013

**Safe and Efficient Shale Gas Exploration and Production E&I Workshop
Amsterdam, the Netherlands**

Enabling Safe & Efficient Shale Gas Exploration & Production



A Responsible Operations Philosophy:

- Utilize sound management practices
- Protect ground water and efficiently manage fresh water resources
- Work with local communities to manage impacts
- Promote transparency and reasonable regulations

An Effective Risk Management Framework:

- Capable, committed workforce with clear accountability
- Well-developed and clearly defined policies and procedures
- High standards of design to reduce or eliminate risk
- Employee and contractor training
- Systematic approach to performance metrics and continuous improvement
- Rigorously applied management systems

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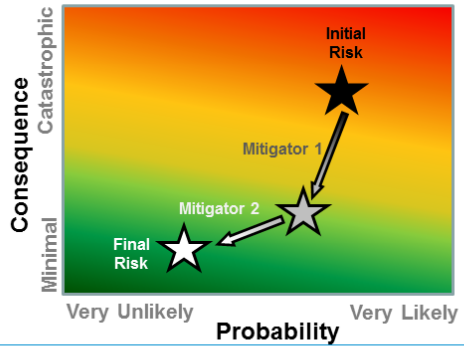
Effective Risk Management

1. Identify: activities that may lead to significant risk if not mitigated
2. Assess: using appropriate data and considering local situation
3. Mitigate: considering social and economic elements

Risk is a combination of probabilities and consequences



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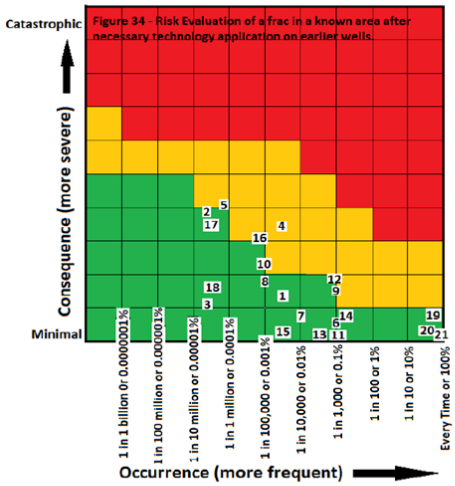
Potential Risks: Shale Fracturing & Development



A recent SPE publication presents an assessment of publicly available data

- Risks can be effectively mitigated and most activities are generally lower risk
- A reasonable and prudent regulatory framework is required to foster responsible operations *by all*

1. *Spill of 130-bbl transport load*
2. *Spill of 500-gallons of liquid concentrated biocide or inhibitor*
3. *Spill of 500-lbs of dry frac chemical additives*
4. *Spill of 300-gallons diesel from diesel-fueled truck accident*
5. *Spill of 3500-gallons fuel from truck accident*
6. *Spill / leak from 500-bbl well site fluid storage tank*
7. *Spill of water treated for bacteria control*
8. *Spill of diesel while refueling pump trucks*
9. *Spill of 500-bbl stored flowback water from frac*
10. *Frac pressures ruptures surface casing at exact depth of fresh water sand*
11. *Frac fluid tubular cooling causes wellhead leak*
12. *Frac opens mud channel in cement in wells < 2000-ft deep*
13. *Frac opens mud channel in cement in wells > 2000-ft deep*
14. *Frac intersects another frac or well within a 1000-ft*
15. *Frac intersects an abandoned wellbore*
16. *Frac to surface through rock strata – shallow well < 2000-ft*
17. *Frac to surface through rock strata – deep well > 2000-ft*
18. *"Felt" earthquake from hydraulic fracturing of magnitude > 5*
19. *Frac changes output of natural seep at surface*
20. *Emissions*
21. *Normal frac operations without significant (reportable) spills, ruptures, leaks*

Source: G. E. King (2012) SPE Paper 152596 "*Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells*"

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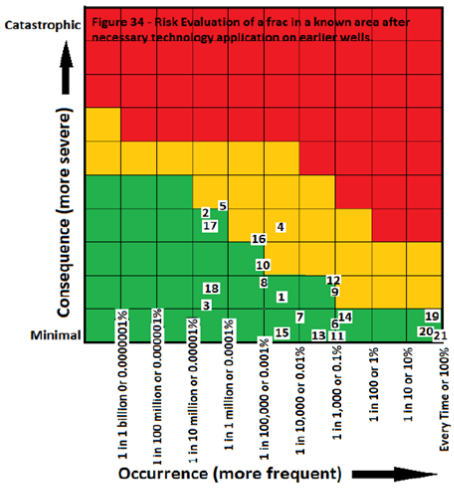
Potential Risks: Shale Fracturing & Development



A recent SPE publication presents an assessment of publicly available data

- Risks can be effectively mitigated and most activities are generally lower risk
- A reasonable and prudent regulatory framework is required to foster responsible operations *by all*

Key risks to consider

- Public nuisances: noise, traffic, dust
- Induced seismicity
- GHG emissions
- Surface chemical spills, material transport accidents
- Subsurface fluid migration due to poor well construction or shallow faults

Source: G. E. King (2012) SPE Paper 152596 "*Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells*"

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Understanding Risk & Mitigation
Potential Water Contamination

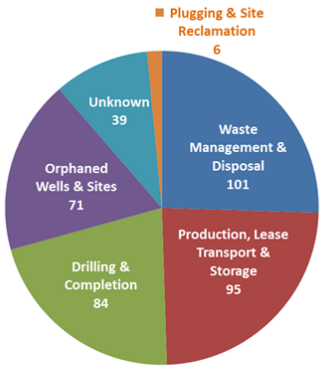
Issue
- Surface release and/or spill of chemicals & fluids
- Unplanned subsurface fluid migration

Data
- GWPC comprehensive review: ~389,000 wells
- Texas (1993-2008) & Ohio (1983-2007)

Risks
- Total documented incidents 396 (~0.1%)
- Diversity of causes / very localized impacts (not broad)
- No incidents from hydraulic fracturing / site prep
- Surface handling (< 0.06%)
- Orphaned wells / legacy sites (< 0.05%)
- Drilling / cementing / completion (< 0.04%)

Mitigation
- Prudent regulation & inspection
- Redundant barriers & containment
- Improved standards for reserve pit construction
- Improved standards for demonstrating well integrity
- Address "orphan" well & "legacy" site issues
- Remediation when issue encountered

GWPC 2-State Review Texas and Ohio
~220,000 Wells Drilled & ~169,000 Wells Plugged
396 Incidents



Source: Kell, S. (2011) "*State Oil and Gas Agency Groundwater Investigations and their Role in Advancing Regulatory Reforms, A Two-State Review: Ohio and Texas*", Ground Water Protection Council, available at *http://fracfocus.org/sites/default/files/publications/state_oil__gas_agency_groundwater_investigations_optimized.pdf*

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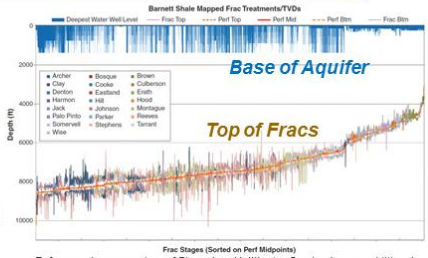
Understanding Risk & Mitigation
Potential Water Contamination

Issue
- Fractures create flow paths to shallow water aquifers
- Fracture pressures open cement channels or faults in shallow wells

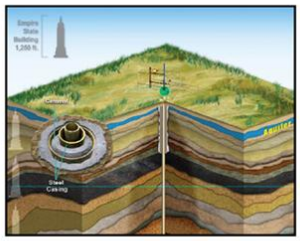
Data
- Microseismic measurements obtained in thousands of fracture treatments
- Extensive (USA) State and Federal investigations

Risks
- Frac chemicals have not been found in any aquifer
- Isolated instances of gas migration in shallow wells due to poor well construction

Mitigation
- Engineered well designs / multiple barriers considering local geology and aquifer location
- Integrity testing of well prior to operations
- Monitoring of frac pressures
- Remediation of well construction issues if encountered



Reference: Image courtesy of Pinnacle, a Halliburton Service (see as additional reference SPE Paper No. 145949)



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Understanding Risk & Mitigation
Potential Air Quality Impact from Emissions

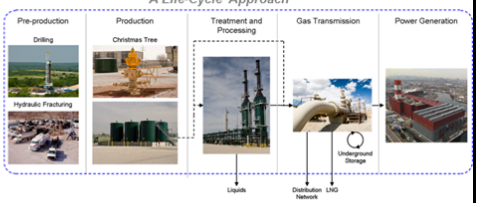
Issue
- Methane has a global warming potential 20-25 greater than CO_2

Data
- Unconventional & conventional gas similar, and much better than coal
  - + *Natural Gas: 458-511 kg CO_2eq/MWh generated (10 studies)*
  - + *Pulverized Coal: 900-1600 kg CO_2eq/MWh generated (6 studies)*
  - + *Only one study found that suggests coal < gas*
  - + *More data upcoming: UT-EDF study and EM LCA*

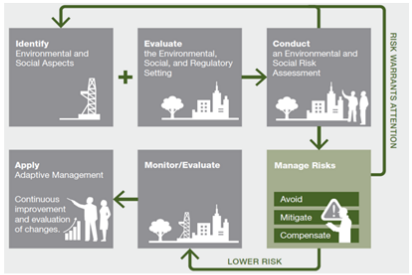
Risk
- Long-term impact of GHG emissions (coal vs. gas)
- Personal health exposure to pollutants
  - + *Extensive measurements in City of Ft. Worth (Barnett Shale) clearly show emissions do not reach levels that have been observed to cause adverse health effects.*

Mitigation
- Country regulations and directives
- Application of Company Environmental Standards for emissions through the life cycle
- Design right the first time; monitor; and maintain

A Life-Cycle Approach



ExxonMobil's Environmental & Social Management Process



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Understanding Risk & Mitigation
Induced Seismicity from Injection Operations

Issue
- Seismicity can be induced or triggered when stress or pore pressure changes promote slip along a fault

Data
- USA National Academy of Sciences comprehensive study
- DECC (U.K.) report of Bowland shale
- BCOGC (Canada) report on Horn River

Risk
- Injection: 7 reports of M > 4.0 events in over 30,000 wells (localized moderate impact)
- Fracturing: 3 reports for >> 1,000,000 treatments (no significant damage or injury)

Mitigation
- Avoid high-pressure large volume injection directly into significant and active faults
- Consider a "stoplight approach" based on local conditions when a significant risk is demonstrated

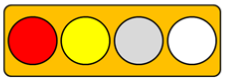
NATIONAL ACADEMY OF SCIENCES

NAS has recently examined induced seismicity across multiple energy sectors. Three major findings were published from this study [1]:

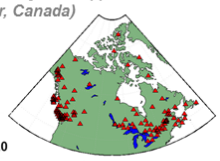
1. "The process of hydraulic fracturing a well as presently implemented for shale gas recover does not pose a high risk for inducing felt seismic events
2. Injection of disposal of waste water derived from energy technologies into the subsurface does pose some risk for induced seismicity, but very few events have been documented over the past several decades relative to the large number of disposal wells in operation; and
3. CCS, due to the large net volumes of injected fluids, may have potential for inducing larger seismic events."

(1) NAS (June 2012), "Induced Seismicity Potential in Energy Technologies", http://www.nap.edu/catalog.php?record_id=13355

Example of a Stoplight System Approach (Horn River, Canada)



Suspend Operations	$M_L \geq 4.0$
Proceed with Caution	$2.0 \leq M_L \leq 4.0$
Proceed as Planned	$M_L \leq 2.0$



Canadian National Seismograph Network, Active Stations, 2/6/13

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Social & Community Concerns
Collaboration & Communication

Issue
- Development nuisances are emotional and real issues & technical responses are not very appeasing
- Public concerns and uncertainty exist with both exploration and development

Data
- Urban & rural development experience in N. America
- Exploration phase in Europe

Risk
- Resource access limited
- Economic development constrained

Mitigation
- Proactive community engagement
- Careful site selection and preparation
- Multi-use drilling pads
- Spill containment / noise barriers
- Regulatory / emissions compliance
- Reclamation / landscaping

Citizen "Real World" Concerns	Industry's "Technical" Responses
Will my water be contaminated?	Well design and integrity Surface water management
Will my children get sick?	Exposure pathways
Will my faucet water catch on fire?	Thermogenic and biogenic methane

Urban vs. Rural Development

Town Hall Meetings

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Backup Material

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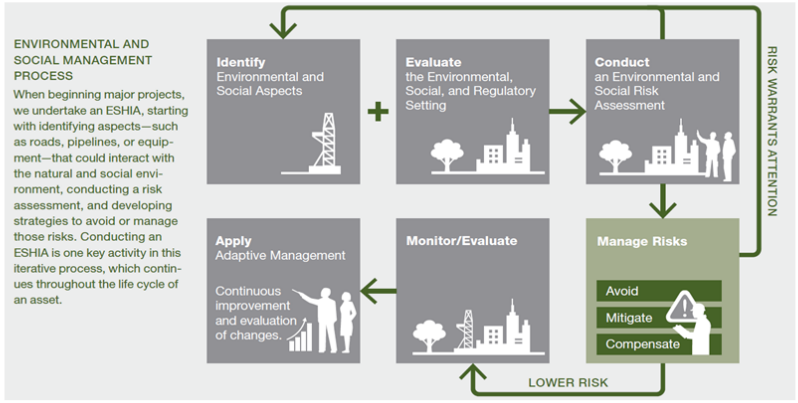
Environmental, Socioeconomic, Health Impact Assessments



ESHIAs identify key risks that could be encountered throughout the asset life cycle and develop strategies to appropriately manage these risks. ESHIAs are on the critical path of most project schedules since their submission and approval are often tied to the issuance of major permits or approvals.

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Sources of Data*

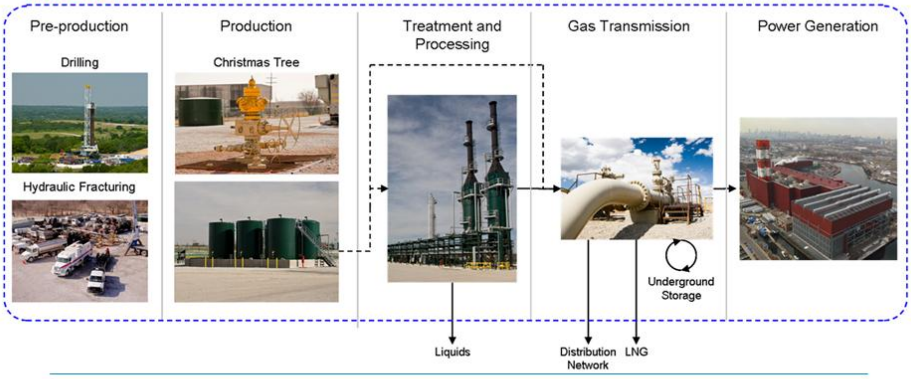
- XTO Flowback Data
- XTO Water (hydraulic fracturing)
- XTO & XOM Decline Curves
- XTO Diesel Use for Pumps/Trucks (not downhole injection)

- EPA Emission Factors for Fugitives and Venting
- XTO Engine CO_2 Emission Data
- XTO Gross Production Data

- EPA CH_4 Emissions from "Processing", 2011
- EIA U.S. Gross Production Data
- XTO Reboiler Fuel Data

- EPA CH_4 Emissions from "Transmission", 2011
- EIA U.S. Gross Production Data
- Published Caterpillar Engine and Turbine Heat Rate Data

- EIA Electricity Generation Data File
- NREL Technical report on power plant water usage



* XTO specific information in red

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11.15 Environmental Aspects of Hydraulic Fracturing Treatment Performed on the Łebień LE-2H Well

Monika KONIECZYNSKA, PGI

11.15.1 Abstract

In order to make a first step to verify if an exploitation of shale gas may create risk for natural environment in Europe, detailed studies of changes in environmental conditions were carried out in area of the first horizontal exploratory well in Poland, in which the Lane Energy company performed full-scale hydraulic fracturing in the middle of year 2011. The studies were conducted on initiative of the Polish Ministry of the Environment.

The Łebień LE-2H well is 4,075 m deep, with horizontal section of 1,000 m. It is located near Łebień in the Pomerania voivodeship, northern Poland. This is typical rural area, located on watershed. The main potable groundwater horizon occurs at the depth 10 to 20 m below land surface but the local population also uses water from shallower horizons.

The hydraulic fracturing was performed by Schumberger in 13 intervals of horizontal section of the well between 19th and 28th of August, 2011. Over 17 000 m3 of water were mixed with 1 300 Mg of proppant (quartz sand) and 462 m3 of chemical substances for on-line preparation of fracking fluid and injected all together into the horizontal section.

The project was coordinated by the Polish Geological Institute and the team consisted of geologists and hydrogeologists from the PGI as well as specialists from Regional Inspectorate for Environmental Protection in Gdańsk, the Institute of Geophysics of the Polish Academy of Sciences, Biology Division of the Faculty of Environmental Engineering of the Warsaw University of Technology and Oil and Gas Institute in Cracow. Over 30 specialists took part in the field works, and about 30 - in laboratory studies.

The team of specialists examined environmental conditions before, during and after the hydraulic fracturing. Field investigations were preceded by deep study of existing environmental data, technical details of the planned fracking job as well as compliance of the planned work with all administrative decisions and permits.

The studies were comprehensive, covering air, soil gas, surface water and usable groundwater, soil, noise level and induced seismicity. A special attention was paid to the presence of the major component of natural gas, that is methane, and radioactive radon. The presence of methane would indicate inappropriate well completion allowing migration of gas from shale rock layers subjected to hydraulic fracturing. Radon is fairly common in rocks in northern Poland but, as suggested by some authors, may also escape from gas-bearing shale rock series.

The studies carried out on such scale for the first time in Poland did not show any changes in the natural environment which could be linked with the hydraulic fracturing. No significant air pollution due to work of power generators was noticed. Neither methane nor radon concentration increase were detected. Seismic stations did not record any quakes during the time of fracturing, except of this from South-East Asia. Also analyses of water from the local creek and 9 water wells did not show any changes in chemical composition as found before the hydraulic fracturing. Only noise level

turned to be intensified from time to time but only in the direct proximity of the well pad equipment.
The studies also covered management of waste and flowback fluids. As expected, a part of injected technological fluid (nearly 3 000 m3) came back to the surface. The chemical composition of flowback, as a mutual result of chemical additives and contact with shale formation itself and with rest of drilling mud, appeared to be very unstable, enriched in chlorides, potassium, barium, sodium, iron, TOC, detergents. The analyses showed increased toxicity of the flowback in relation to some groups of organisms (esp. crustaceans, fish and plants). The major part of the flowback was subjected to pre-treatment along a special treatment line on the well pad in order to be reused in hydraulic fracturing to be performed in another well. The rest as industrial liquid waste was sent to be subjected to specialized methods of utilization. It should be noted that the technological liquids did not have any contact with the environment during the whole process and were subjected to continuous supervision.
All the operations carried out at the well pad were conducted in the way minimizing risk of negative impact on ground water. This includes recycling of the flowback fluids, storage of waste in leak-proof containers and protection of land surface with concrete plates and liners made of plastic film.
It should be added that the use of large quantities of water in hydraulic fracturing operations did not cause any depletion in groundwater resources in the Łebień well area. Water was being collected constantly for several months in quantities consistent with the water rights permit and stored in leak-proof reservoirs.

11.15.2 Presentation

Safe and Efficient Shale Gas Exploration and Production, Best Available Technologies and R&D Projects for Europe

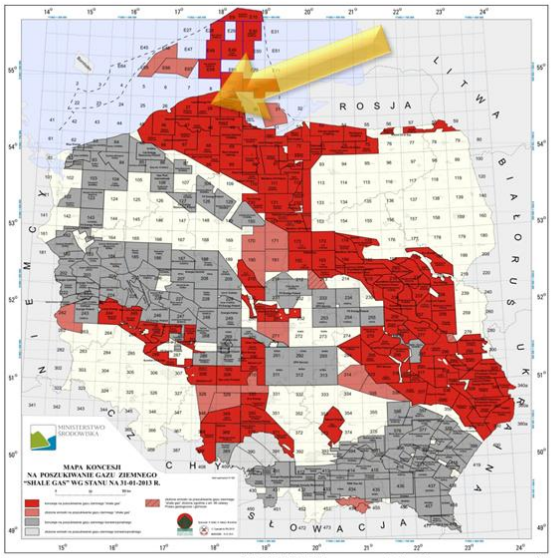
„Environmental Aspects of Hydraulic Fracturing treatment performed on the Łebień LE-2H Well"

Concept, methodology, results and outcomes of environmental impact study of the first horizontal hydraulic fracturing in Poland.

Dr. Monika Konieczyńska
Polish Geological Institute – National Research Institute
Polish Geological Survey

Amsterdam, 7-8 March 2013

Map of Concessions for Prospecting and Exploration of Natural Gas in Poland



as of 31/01/2013, source:http://www.mos.gov.pl

Polish Geological Institute
National Research Institute
www.pgi.gov.pl


Łebień LE-2H
3LEGS Resources
MINISTERSTWO ŚRODOWISKA
PSG
PAŃSTWOWA SŁUŻBA GEOLOGICZNA
PSH
PAŃSTWOWA SŁUŻBA HYDROGEOLOGICZNA
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Łebień LE-2H
http://www.pgi.gov.pl/en/all-events/4087-environmental-impact-hydraulic-fracturing-lebien.html
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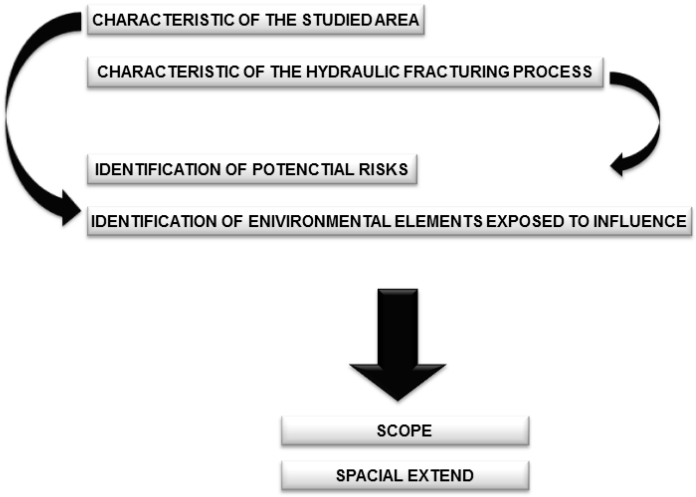
METHODOLOGY



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CHARACTERISTIC OF THE STUDIED AREA

METHODOLOGY

- Geomorphology
- Geological structure
- Hydrogeological conditions including potable water reservoirs
- Land use patterns and landscape values
- Demography, employment structure
- Buildings and technical infrastructure
- Areas under legal protection

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CHARACTERISTIC OF THE STUDIED AREA

METHODOLOGY

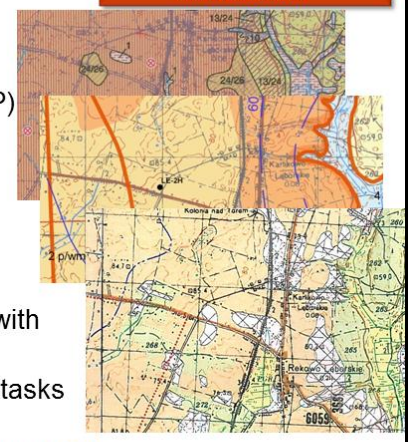
Serial maps in the scale of 1:50 000:

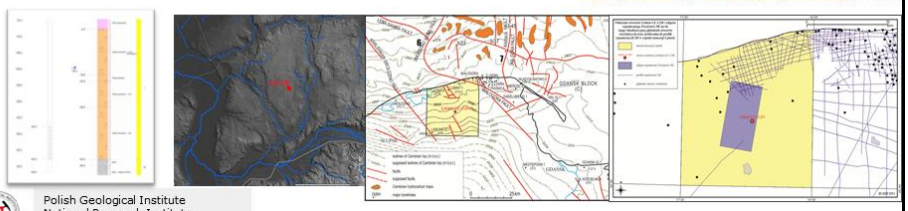
- Detailed Geological Map of Poland (SMGP)
- Hydrogeological Map of Poland (MHP),
- Geo-Economical Map of Poland / Geoenvironmental Map of Poland (MGGP/MGP)

Existing Databases

Dedicated maps of different geological data with tectonics

Documentation done in the area for different tasks





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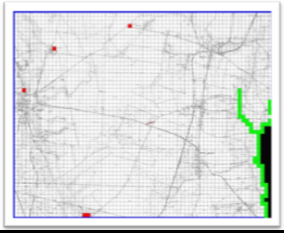
DOCUMENTATION AND FIELD DATA COLLECTION

METHODOLOGY

- Collection of all administrative decisions concerned with concession, drilling and planned fracking job:
  - On water intake
  - Amendment to mining work plan
  - On waste production and disposal
  - On H&S procedures
- Collection of data concerned with chemicals, proppant and fracking job plan
- Inventory of hydrogeological objects within radius of 3 km from the well pad
- Validation of water wells as a representative groundwater sampling sites
- Groundwater level measurements and hydrogeological modeling
- Choice of representative surface water sampling and measurement site
- Choice of induced seismicity measurement stations positions
- Preparation of soil gas sampling grid
- Inventory of contemporary methane production areas (swamps, bogs, wetlands)
- GPS measurements of all sites and objects
- Photographic documentation



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CHARACTERISTIC OF THE HYDRAULIC FRACTURING PROCESS

METHODOLOGY

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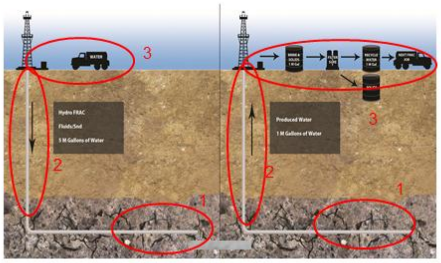
IDENTIFICATION OF POTENCTIAL RISKS

METHODOLOGY

- Theoretical pollutants migration routes
- Possible migration of shale gas



- Induced Seismicity
- Gases and dust from engines and equipment
- Noise
- Radioactivity
- Water and waste management
- Serious technical accidents and natural hazards

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IDENTIFICATION OF ENIVIRONMENTAL ELEMENTS EXPOSED TO INFLUENCE

METHODOLOGY

- Atmospheric Air
- Soils and subsoils
- Human health and living conditions
- Groundwater
- Landscape
- Land surface
- Surface water bodies
- Wildlife and protected habitats

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ASSUMPTIONS FOR A SCOPE OF SURVEY

METHODOLOGY

- State of the environment before the start of the hydraulic fracturing job - as a benchmark
- Observations and measurements during the hydraulic fracturing process and gas tests
- State of the environment after the hydraulic fracturing process and production tests

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THE ACTUAL SCOPE OF SURVEY

METHODOLOGY

Date	Stages of work at Łebień drilling pad	Stages of studies of the research team
13.06 - 18.07.2011	End of drilling, drilling rig dismantling	Stage I – site inspection, analysis of available materials, preparation to the studies
19.07 - 31.07.2011	Drill site preparation for fracturing treatment	Stage II – defining background for analyses of impact on air, land surface, surface and groundwater; start of seismic surveys
01.08 - 18.08.2011	Transport and assembling equipment for fracturing, safety tests	
19.08 - 28.08.2011	Hydraulic fracturing	Stage III – measurements of concentrations of air pollutants and noise level, seismic surveys, sampling groundwater and technological fluids for laboratory analyses
31.08 - 07.09.2011	Drilling out the plugs, well pressure reduction	
08.09 - 22.09.2011	Production tests, injection of nitrogen lift	Stage IV – analyses of soil gas, shale gas sampling, measurements of emissions, sampling groundwater and technological fluids, chemical analyses of groundwater samples, chemical and toxicological analyses of technological fluids
23.09 - 13.10.2011	Demobilization of equipment, securing well and well site, waste disposal	Stage V – sampling groundwater and technological fluids, continuation of chemical and toxicological analyses of sampled groundwater and fluids, analyses of soil gas samples, continuation of measurements of soil gas and air pollution, gathering data on waste production and fate and water balance

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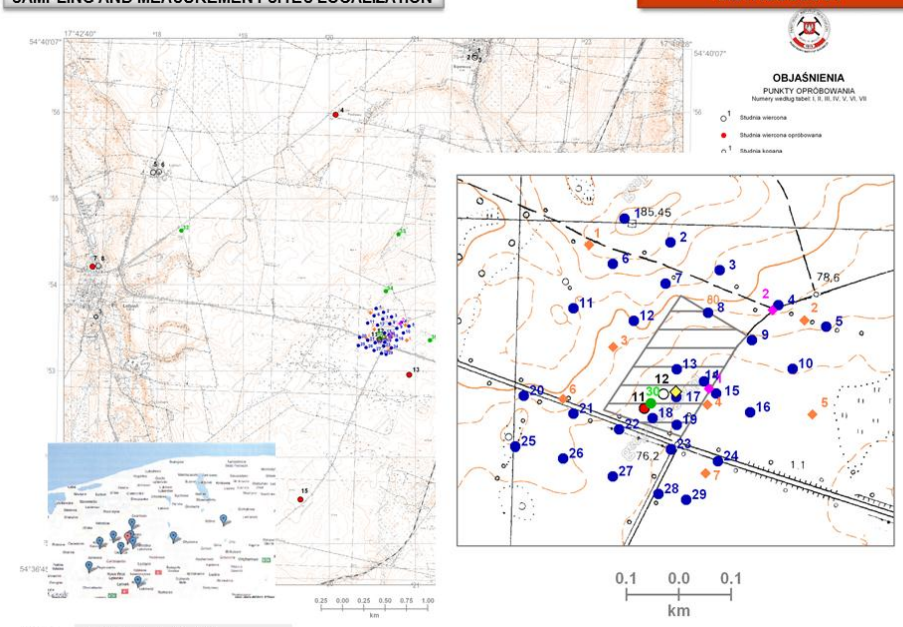
SAMPLING AND MEASUREMENT SITES LOCALIZATION

METHODOLOGY



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METHODOLOGY

Seismic Monitoring

Seismic monitoring conducted by Institute for Geophisics of Polish Academy of Science between 15th of July and 30th of September with use of 10 mobile seismic station located from 1 to 25 km from the well pad.

Air and Noise Pollution

The responsibility of Regional Environmental Protection Inspectorate in Gdańsk.

Measured: sulfur dioxide, nitrogen oxides, benzene, methane, carbon oxide and hydrogen sulfide with mobile Draeger CMS analyzer, colorimetric method in 3 series of measurements in 3 different sites. Results were standardized for temperature of 0° C, pressure of 1013,25 hPa).

In addition the passive samplers exposed twice for one month measured loads of sulfur dioxide, nitrogen dioxide and benzene near well pad.

Measurements of noise level performed on three sites:

- on the well pad,
- next to it, direction towards closest human settlings
- on the first farm in the nearby village

METHODOLOGY

Radioactivity – Radon level

Level of radon (^{222}Rn) in soil gas was measured on site in regular grid around the well pad with RADON DETECTOR LUK-3B. Soil gas samples were collected from the depth of approx. 0.8 m. Measurements were performed before the fracking and repeated after end of production tests and well closure.

Potential emissions of shale gas

Measurements of methene concentration in soil gas were performed in the same regular grid around the well pad with portable Seitron detector and dedicated sampling set. Methane concentration was also measured in all wetlands within the radius of 5 km from the well. On the well pad a fixed point with *direct well* screen was instaled for measurements of methene level in unsatureted zone next to the well.

After hydraulic fracturing, specialists from Oil and Gas Institute sampled soil gas in the same sampling grid for laboratory analyses of chemical composition and carbon and hydrogen isotopic ratio.

Two samples of shale gas from the well were collected in order to compare the characteristics of hydrocarbons from shale and from soil gas.

METHODOLOGY

Surface and Groundwater

- Based on modelling the area of potential impact on groundwater was defined
- 20 of dug and drilled water wells were inspected, 9 of them chosen as representative for groundwater sampling
- Groundwater was sampled before the fracking and after the end of production tests
- Chemical characteristic of groundwater was assessed based on analyses of 47 inorganic and 49 organic parameters
- Further monitoring scheme was prepared

- The local creek water was sampled 3 times – before the operation, after frack job and after production tests
- Water from artificial ponds treated with chemicals against biota growth had been sampled straight before it was taken for the fracking

METHODOLOGY

Technological fluids and waste

During the hydro-fracking and production tests data on quantity of water used and quantity and chemical characteristics of flowback were gathered. Over 20 samples of fracking fluid and raw and pre-treated flowback were collected to analyze how rock contact might influence the chemical composition and eco-toxicity of the flowback.

Documentation on chemical storage and labelling was also prepared.

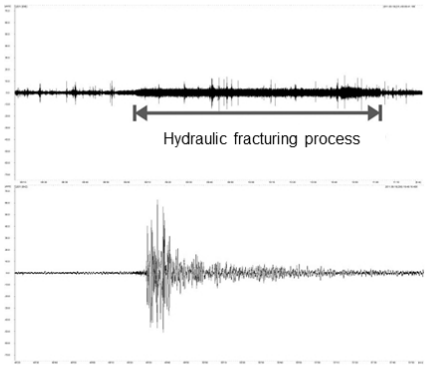
Chemical analyses of collected fluids were performed in Central Chemical Lab of PGI. Eco-toxicity was measured in Biology Division Lab in Environmental Engineering Faculty of Warsaw University of Technology.

The PGI specialists identified the way of handling waste especially from the fracking job and its compliance with administrative decisions and permits. Some solid waste was sent as a component for capping of a closed municipal waste disposal site.

SEISMIC EVENTS

RESULTS

- ✓ There were not recorded any seismic quakes which could be linked with the fracturing operations
- ✓ The studies carried out during four weeks before the fracturing and four weeks after the fracturing also did not detect any quakes, except for the earthquake in SE Asia



- ✓ Ground vibrations generated by equipment working at the well pad did not pose any risk for human health, nor for buildings and technical infrastructure

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NOISE

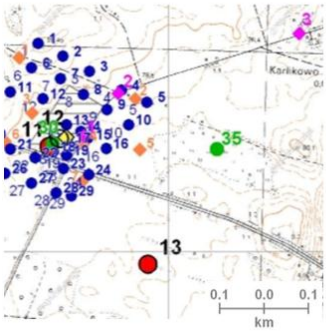
RESULTS

ANNEX No. 4
Measurement points of noise level and obtained results

Lp.	No. as shown on map (Annex 1)	Location	Results of measurements dB			Norms dB
			19.07.2011 *before fracturing*	19.08.2011 *during fracturing*	09.09.2011 *during gas tests*	
1	1	Drilling pad boundary (at fence of technological area)	38,1	62,9 – 76,0	56,4	nn
2	2	By the road to Karlikowo Łęborskie village	36,9	68,6	48,3	nn
3	3	Close to houses of Karlikowo Łęborskie village	36,2	53,9	44,0	55,0

nn – not normalized

EXPLANATIONS
SAMPLED POINTS
Numbers as in Annexes no. 3, 4, 5, 8 and 9
Measurement point of noise emitted by equipment and installations



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EMISSIONS

RESULTS

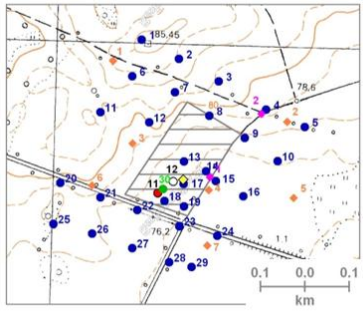
ANNEX No. 3
Measurement points of air pollution and obtained results

Lp.		1	2	3	4	5	6	7	Reference concentrations*
No. as shown on map (Annex 1)		3	4	5	2	1	6	7	
Date / period		19.VII.2011	19.VIII.211	30.VIII.2011	VIII – IX 2011	VIII – IX 2011	VIII – IX 2011	VIII – IX 2011	
Measurement		Draeger CMS analyser	Draeger CMS analyser	Draeger CMS analyser	Passive samplers	Passive samplers	Passive samplers	Passive samplers	
Sulfur dioxide	µg/m³	< 517	< 517	< 517	6.05	6,3	5.9	20,2	350
Nitrogen dioxide		< 646	< 646	< 646	7,9	5,71	4,56	3,99	200
Benzene		< 259	< 259	< 259	0.58	1,03	0,6	0,59	30
Methane		< 25 860	< 25 860	< 25 860	-	-	-	-	3 000
Carbon monoxide		< 6 465	< 6 465	< 6 465	-	-	-	-	30 000
Sulfur hydrogen		< 259	< 259	< 259	-	-	-	-	20
Carbon dioxide	ppm	450	380	370	-	-	-	-	*Control value*

* After Regulation of the Minister of Environment of 26 January 2010 on reference values for certain substances in the air (Journal of Laws of 2010, No. 16, item 87

EXPLANATIONS
SAMPLED POINTS
Numbers as in Annexes no. 3, 4, 5, 8 and 9

- Sampling point for methane and radon in soil air
- Sampling point for methane in soil air
- Measurement point of air pollution
- Measurement point of noise emitted by equipment and installations



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POSSIBLE SHALE GAS EXHALATIONS

RESULTS

- ✓ Radon was abundant in soil gas in quantities of less than 10-50 kBq/m^3 due to radioactive decay of uranium in Scandinavian rock material brought by the glacier. No increase in radon concentration in soil gas was detected after fracturing.
- ✓ Methane concentration background values were very low (0-10 ppm) in proximity of the well, except for waterlogged and peat soils, where biogenic methane reached levels of some hundreds ppm. No changes in this situation after frack job happened.
- ✓ Contemporary biogenic wetland soil gas origin was confirmed by results of isotopic studies of carbon in soil carbon dioxide.
- ✓ Any shows of shale gas migration directly after the fracturing treatments on the well bore were not revealed.

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TECHNOLOGICAL FLUIDS AND WASTE

RESULTS

- ✓ Substances used for frac fluid production were delivered in original packages or containers with identification tags and certificates of origin of a given product as required by the Polish and international law
- ✓ All chemicals had their MSDS required by REACH Directive
- ✓ The flowback fluid from hydraulic fracturing operations was cleaned on filters to remove solid particles and make possible its reuse in further technological processes

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TECHNOLOGICAL FLUIDS AND WASTE

RESULTS

Type of work	Volume of fluid injected	Volume of fluid received	Volume of flowback
	m^3		
Preparation of well bore	324.0	324.0	-
Fracturing	17 784.69	-	-
Drilling out the plugs	3 131.5	3 131.5	805.5
Gas tests	-	-	1 975.2
TOTAL	**21 240.19**	**3 455.5**	**2 780.7**

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IMPACT ON GROUNDWATER

RESULTS

- ✓ Water needed for technical purposes was drawn for months from local Quaternary water-bearing horizon and stored in open-air reservoirs at the well site. Therefore, despite of use of large volumes (above 21 000 m^3) of water in the fracturing operations, the groundwater resources did not diminish in the well area.

- ✓ All the available data did not show any negative influence of these operations on groundwater of the region. Control studies of groundwater in water well situated on the well pad, that is located at the smallest distance from the LE-2H well head, did not show any changes in water quality.

INFLUENCE ON SURFACE WATER

RESULTS

- ✓ All measured concentrations of possible pollution indicators in local creek water did not exceed threshold values established for the first class of water quality
- ✓ No changes in water characteristics were observed during the study
- ✓ Contamination originated from the fracking due to groundwater drainage possible not earlier than in 30 years

OUTCOMES

- The hydraulic fracturing as a stimulating treatment which opens access to shale gas reserves seems not to bear significant immediate influence on the environment, providing that performed in accordance with :
  - the best professional knowledge
  - the legal regulations and standards
  - H&S of work standards
  - correctly and properly issued administrative decisions
- Due to changing conditions and different operational practice, assessment of environmental impact of hydraulic fracturing should be continued on other sites
- The study must be supplemented by long term monitoring including deep water aquifers and geophysical survey of shale formation
- Experience and knowledge gained from such study should assist preparation of legal regulations and administrative procedures

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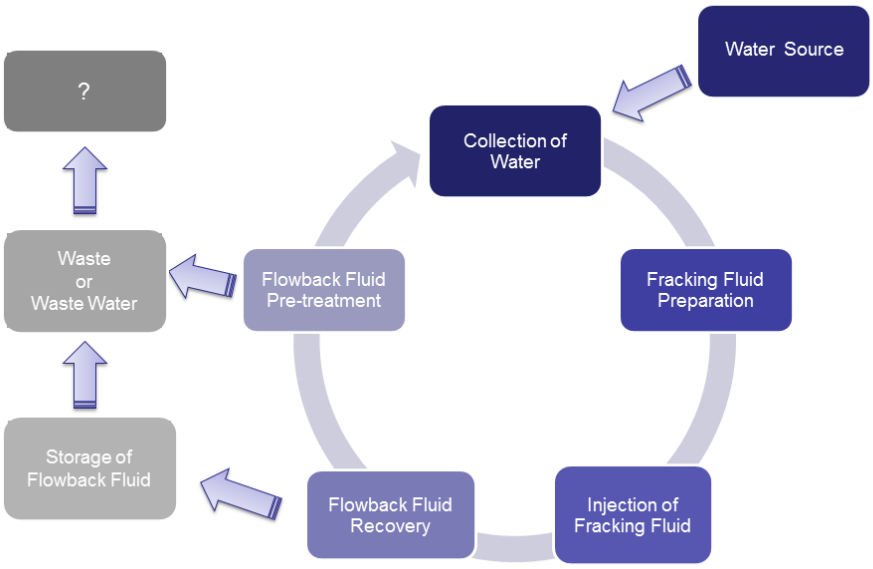
OUTCOMES

Main Identified Problems



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OUTCOMES

Main Identified Problems

✓ In the Łebień case the company received all the required decisions on waste management and fulfilled all the obligations.

But in the future:

- More drilling → cumulative effect
- We expect 180 000 – 360 000 Mg of drilling waste produced in 2013-2017
- Today in Poland operates 35 plants which have a decision on the recovery or disposal for waste of 01 05 subgroup, but they are not dedicated to that type of waste

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OUTCOMES

How to get shale gas with not losing anything

- Responsible legal regulations
- Constant cooperation of science, industry and administration
- Reliable and honest dialog with society and NGOs
- Low emission technologies
- Reasonable use of water resources and further development of techniques minimizing hydraulic fracturing water needs
- Environmental pressure analysis and monitoring

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Thank you very much for your attention
mkon@pgi.gov.pl

11.16 Advanced technologies for water and solid waste treatment in shale gas production

Jan HUPKA, Gdansk University of Technology

11.16.1 Presentation

Safe and Efficient Shale Gas Exploration and Production
Best available technologies and R&D projects for Europe

E&I Workshop
Amsterdam 7-8 March 2013

Advanced technologies for water and solid waste treatment in shale gas production

Jan Hupka & Jan Krzysiek
Gdansk University of Technology
Oil & Gas Center

Rationale

The goal of our research is to point out the areas which, through strategically focused R&D, will allow Poland to become an important participant in the discovery and production process, far beyond geological resource owner and production labor supplier.

Cleaner Fracking, CEN, 15 Oct. 2012

Hydraulic fracturing water (frac fluid)

- Hydraulic fracturing consumes from 10 000 to 20 000 m^3 of water per well.
- A single fracturing operation consumes 2000 m^3 and there are from 5 to 10 operations needed per well.
- Flowback fluid makes from 20 to 30 % of the pumped-in one.

3

Photocatalysis

A photocatalytic reaction can be defined as a chemical reaction induced by photoabsorption of a solid material, or *photocatalyst*, which remains unchanged during the reaction.

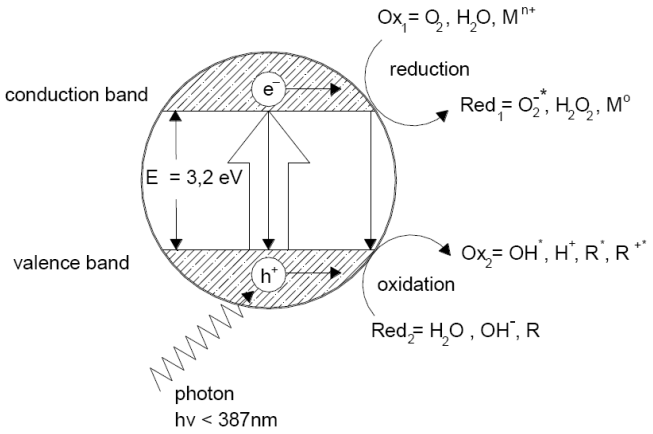
Photocatalysis is now recognized as one of the most important sciences in the development of technologies that can improve the quality of life.

Pollutants degradation efficiency

- **Nature and concentration of pollutant**
- **Incident light intensity**
- **TiO_2 and O_2 content**
- **Reaction medium (gas phase, aqueous phase)**
- **TiO_2 properties:**
  - Surface area
  - Crystalline form (anatase, rutile)
  - Type and amount of dopants
  - Chemical character of dopants

} **photoactivity**

Mechanism of heterogeneous photocatalysis

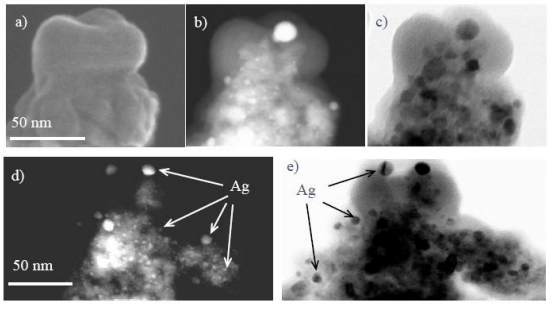


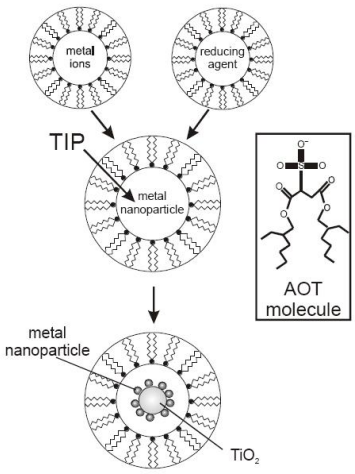
Hydroxyl radicals (•OH) have a short life and one of the highest oxidation potentials (2.74 V)

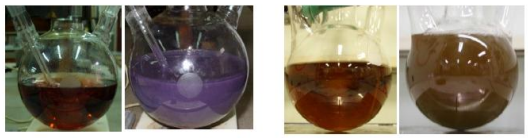
We offer

- Visible light activated photocatalyst
  - doped or modified with metals (Au, Ag, Pt, Co, Fe, Ni, W, rare metals)
  - doped or modified with nonmetals (S, B, N, C)
- Separable photocatalysts
  - immobilized on the surface
  - with magnetic properties
  - oriented structures as thin films
- Novel photoreactor design

Noble metal-modified TiO_2 photocatalyst – microemulsion procedure







Au-TiO_2 nanoparticles Ag-TiO_2 nanoparticles

Photocatalytic decomposition of pollutants in gas and liquid phases

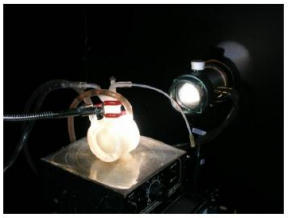
Photocatalyst	Light range	Target pollutant
Water/wastewater treatment		
TiO_2 supported on hollow glass microbeads	Sunlight irradiation (intensity 580 w/m^2)	Ethyl benzene, dodecane
Suspended anatase and rutile; anatase immobilized on glass hollow microspheres	UV irradiation (λ < 400 nm)	Cyanide ions
Ag doped TiO_2	Visible light	Nitrophenol
Suspended anatase and anatase immobilized on glass hollow microspheres	UV irradiation (λ < 400 nm)	Lindane, DDT, methoxychlor
Hybrid of anatase TiO_2 and multi-walled carbon nantubes	UV irradiation (λ = 300 nm)	Methyl orange
Degussa P25	UV irradiation (λ < 400 nm)	Ionic liquids
S-doped TiO_2	Visible light	4-chlophenol
Air purification		
N-doped TiO_2	Visible light	Acetaldehyde
C-doped TiO_2	Visible light (intensity 13.6 mW/cm^2)	NOx
TiO_2 thin film	UV irradiation (intensity 10 mW/cm^2)	2-Propanol

Photocatalyst forms

Suspended

advantages:
high surface area

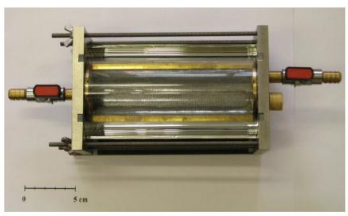
disadvantages:
difficult to separate
difficult to recycle



Immobilized on photoreactor element

advantages:
no need for separation

disadvantages:
difficult to replace after usage
lower surface area

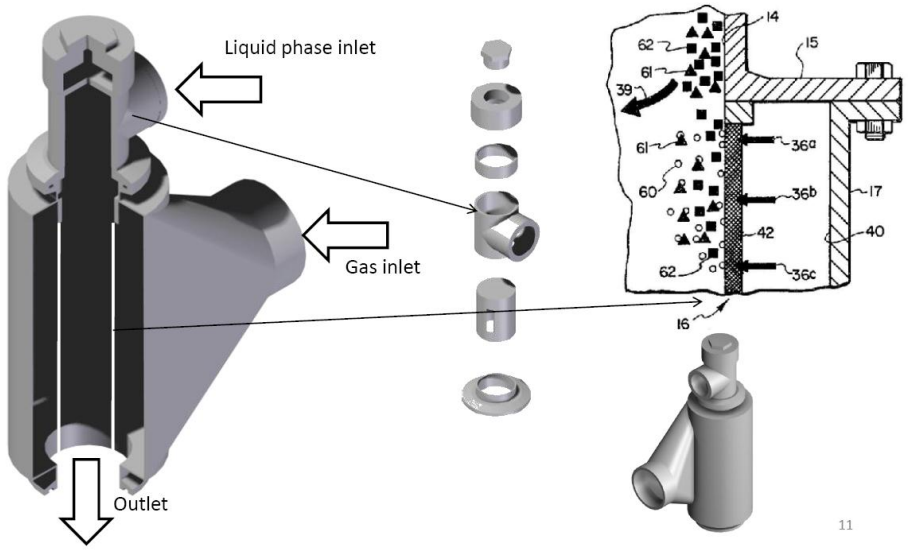


Supported

advantages:
easy to separate
possibility of recycling

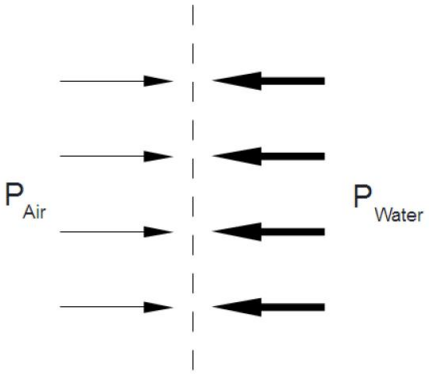
disadvantages:
lower surface area

Spinning Fluids Reactor (SFR)



11

Spinning Fluids Reactor (SFR) – sparging elements



Exerted pressure on sparger inner wall

$$P = \int_{R_{fc}-\delta}^{R_{fc}} \rho \frac{u_t^2(r)}{R_{fc}} d\delta$$

R_{fc} - inner radius of sparging element,
ρ - density of liquid,
u_t - tangential linear liquid velocity,
δ - thickness water

12

Spinning Fluids Reactor (SFR) – thickness of liquid on sparging elements

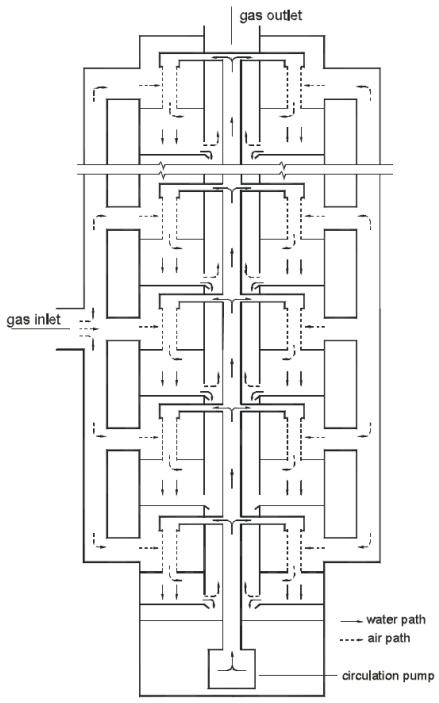
No.	Wall	Thickness of liquids film (mm)
1	Cylinder	2.5
2	Cone 1.5°	11.0
3	Cone 3.0°	15.6

13

Mobile system for research on environmental technologies and analysis

An automatic mobile equipped with two 600 dm^3 and one 1200 dm^3 cylindrical tanks and several new type SFR in series or in parallel.

Instalacja podczas prób oczyszczania powietrza z systemu wentylacji hal technologicznych w ZF POLHARMA S.A w Starogardzie Gdańskim



20.000 m3/h gas phase treatment SFR multi-column

15

Deep bed filter

Utilization of drill cuttings – lightweight aggregates

Photo: drillingcontractor.org

Academic Computer Centre in Gdansk (CI TASK)

Xeon QuadCore based cluster *'Galera'* - 1344 Intel Xeon QuadCore processors (5376 cores), 25 TB total system memory, 100 TB disk storage. Mellanox InfiniBand interconnect with 20 Gb/s bandwidth.

Thank you for your attention.

11.17 Community relations in shale gas development. Examples of good practices from Poland

Tomasz GRYZEWSKI, Talisman

11.17.1 Abstract

In partnership with San Leon Energy, Talisman holds three exploration concessions in the Baltic Basin of Poland, with a total area of over 2500 sq. km

Three concessions provide Talisman with an exposure to a range of geological objectives, thus diversifying the high level of risk associated with exploration in a complex region with sparse geological data.

Talisman believes that shale development has the potential to provide energy-supply certainty and security across the globe. As such, our company developed Shale Operating Principles to support our ongoing commitment to the responsible development of shale resources.

Our Principles focus on three key areas:

Responsible Operations, Mutual Benefit and Transparency and Collaboration.

- We recognize that shale development impacts communities in which we operate, and we are committed to actively engaging stakeholders to identify opportunities to mitigate negative impacts.
- Stakeholder Engagement is a key part of our Shale Principles:
- We engage stakeholders to build trust, understanding and a positive working relationship.
- We engage in meaningful dialogue to understand local needs and priorities.
- We engage the public to understand their concerns and to factor the mitigation of impacts into our plans and activities.

The Social Impact Assessment (SIA) study

THE SIA is a compilation of the Desk Top research of publicly available documents – municipalities, villages, regions development plans, macro economies of the region, any possible chracteristics of the region, village that we intend to lease a land acreage and start exploratory drilling – with local visits and face – to face talks with indentified influential individuals – either formal (government) and informal (local businessmen, church rectors, board members of local associations).

One of the outcomes of the SIA is a SWOT analysis of the region, county and local communes. It is being drawn from the point of view of future talks with local vojts (gmina leaders) and village leaders when we would be aiming for such a cooperation that would deliver a WIN – WIN situations – so satisfy both parties – the investor and local communes. !

The Good Neighbour Program is a common sense approach to assist in addressing concerns that are important to landowners and other stakeholders.

These concerns are being indentified in the final SIA research.

Through the implementation of the Good Neighbour Program, we take action to:
- limit environmental impacts
- limit noise, light and traffic resulting from our operations
- hold our contractors accountable
- investigate, act and resolve concerns
- implement our Local Economic Engagement Strategy

GNP is a field driven and field owned initiative, which means that each program is tailored to the needs of the impacted local community.

11.17.2 Presentation

Community Relations in Shale Gas development

Examples of good practice from Poland

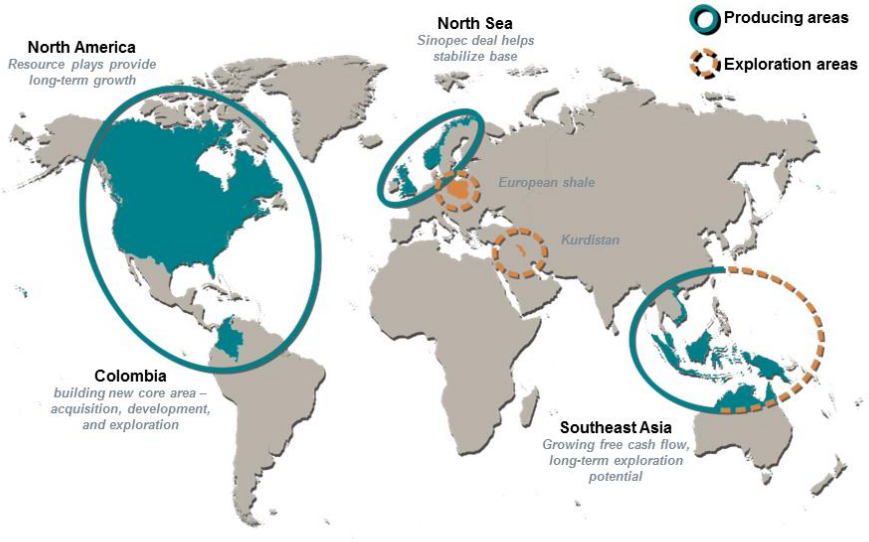
Joint Research Centre's Workshop;
Shale Gas in Europe
Amsterdam 8th March, 2013

TALISMAN ENERGY

KEY LEARNINGS based on CASE STUDIES

- How to minimise local impact in shale gas exploration projects
- Be transparent but exercise caution
- How to gain acceptance of local administartion and communities
- How to build trust and cooperation for mutual benefit in local areas

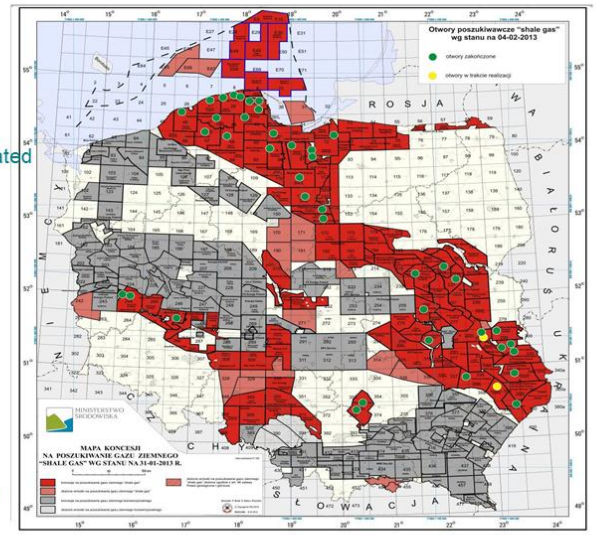
TALISMAN ENERGY – FOCUS AND UNLOCK VALUE



DISCOVERING SHALE GAS - CURRENT STATUS

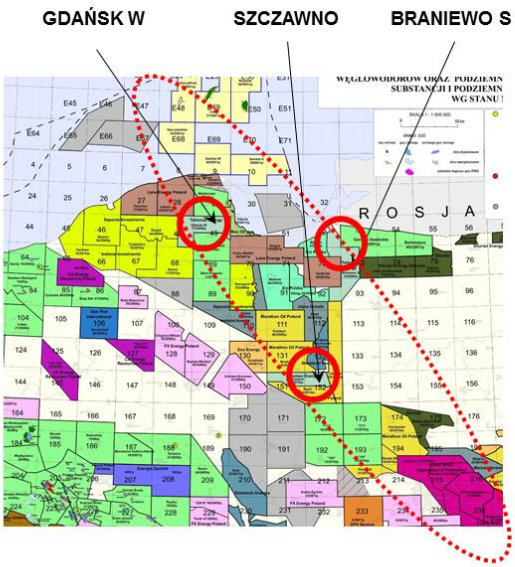
MINISTERSTWO ŚRODOWISKA

- 111 concessions for unconventional hydrocarbons allocated
- 40 exploratory wells have been already drilled
- 2 wells are drilled
- 10 were stimulated (8 vertical and 2 horizontal)
- 270 wells are planned till the year 2020



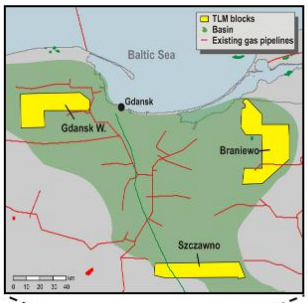
4 February 2013.

TALISMAN ENERGY – Polish Concessions



- In partnership with San Leon Energy, Talisman holds three exploration concessions in the Baltic Basin of Poland, with a total area of over 2500 sq. km
- Three concessions provide Talisman with an exposure to a range of geological objectives, thus diversifying the high level of risk associated with exploration in a complex region with sparse geological data.

ACTIVITY TO DATE - POLISH EXPLORATORY CONCESSIONS

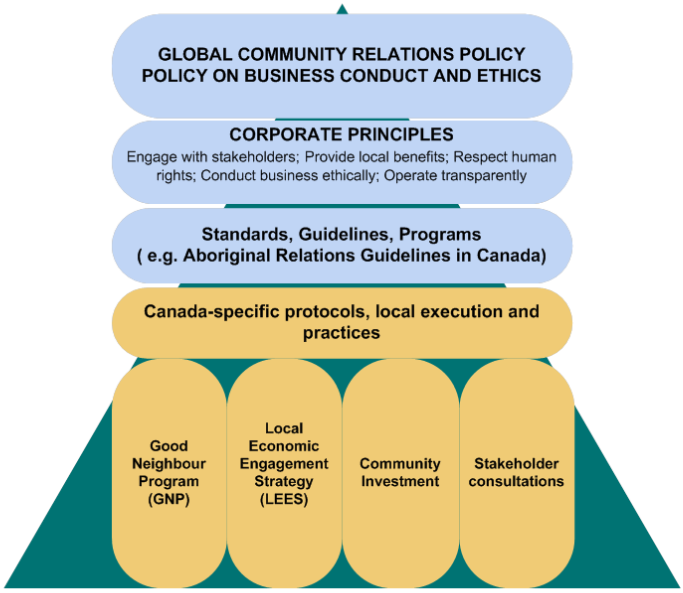


Location	GDANSK W	BRANIEWO	SZCZAWNO
acreage	894,41 km2	1042,69 km2	603,40 km2
location	Lewino - 1	Rogity-1	Szymkowo - 1
depth	3,6 km	2,8 km	4,5 km
status	Vertical drilled Nov 2011	Vertical drilled Feb 2012	Vertical drilled June 2012

TALISMAN ENERGY

TALISMAN ENERGY – SUCCESS DRIVERS

CORPORATE RESPONSIBILITY AT TALISMAN ENERGY

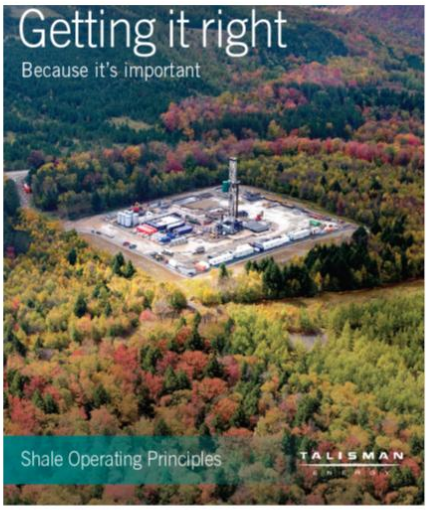


TALISMAN SHALE OPERATING PRINCIPLES

Responsible Operations
- Committed to our Global Community Relations Policy to minimize impacts on the environment and communities
- Proactively engage stakeholders when planning and conducting our activities
- Endeavour to be the operator of choice, and hold our contractors accountable to our Standards and Principles

Mutual Benefits
- Committed to delivering economic and development opportunities through our Local Economic Engagement Strategy
- Promote the development of communities by sharing economic benefits

Transparency and Collaboration
- Work with stakeholders in an open and transperent manner
- Conduct our business to the highest ethical standard in accordance with our Policy on Business Conduct and Ethics



Case Studies

1. Social Impact Assessment

2. Good Neighbour Program

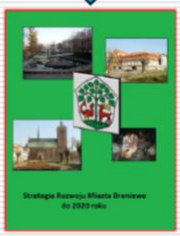
3. Canadian Wonders – English Language Project

SOCIAL IMPACT ASSESSMENT – implement its findings !

Social Impact Assessment – Talisman Energy

Local Community Research

Analysis of Official Documents



Local Government

The Most Effective Tool to Communicate with Local Communities

SOCIAL IMPACT ASSESSMENT 1

INSTITUTE OF INNOVATION FOUNDATION

INSTYTUT Innowacji

TALISMAN ENERGY

Characteristics of the rural commune:

Sierakowice is a rural commune located in kartuski powiat (pomorskie voivodeship). Commune authorities and main administrative and trade representatives reside in Sierakowice village. It is characterized by typical small-town settlement. There are no industry sites. Economy in the commune is based on craft and service with multi-generation enterprises. Unemployment rate is relatively low (compared to national average) and reaches ca. **8-9%**. The commune is amongst the wealthiest in pomorskie voivodeship, thus its popular name „Kashubian Switzerland".

The commune is inhabited by **18,000** people (Sierakowice village – 7000), that is **98,7 per km²**. Sierakowice rates among first third communes with the highest birth rate (**11 ‰**). Inhabitants are predominantly of Kashubian minority (**98%**). Both Polish and Kashubian are working languages (from 2007), the latter being used by **40% of inhabitants.**

Commune's surface stretches over **182,36 km²**. There are 30 villages and 39 hamlets; the commune includes 22 so called 'sołectwo' administrative units; four villages do not belong to any of them.

3

SOCIAL IMPACT ASSESSMENT 2

INSTITUTE OF INNOVATION FOUNDATION

INSTYTUT Innowacji

TALISMAN ENERGY

SWOT Analysis in Sierakowice rural commune:

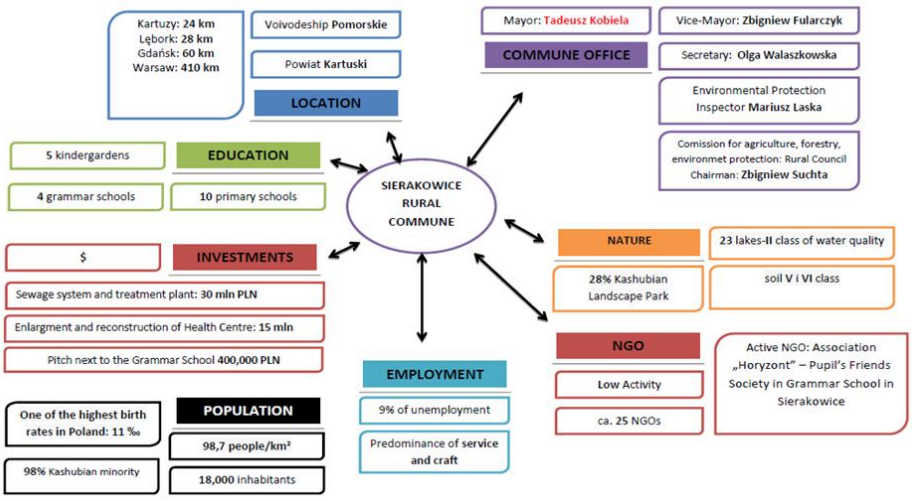
ADVANTAGES	DISADVANTAGES
-richness of inhabitants and the rural commune -strong local government -high birth rate -multi-generation enterprises -plantation of strawberries, developed husbandry and poultry sector -Kashubian culture and traditions -Kashubian Lanscape Park -many lakes -farmlands where investments can be developed	-overpopulation of grammar schools -alcohol/drug abuse among youth -lack of cultural infrastructure for young people (except for schools, one culture centre and church) -fragmented farms, soil of poor quality -lack of gas pipelines -lack of bypass road in Sierakowice
OPPORTUNITIES	**RISKS**
-development of farm tourism -location in the centre of the voivodeship -developed international cooperation -funds from EU and other sources	-limitations due to the existence of landscape parks -increasing environment pollution
SUGGESTED ACTIVITIES FOR TALISMAN ENERGY (selected)	
-Implementation of the project „Canadian Wonders" -Organisation of series of meetings with local leaders, media representatives and inhabitants in order to present the process of search for and extraction of shale gas	

SOCIAL IMPACT ASSESSMENT 3

INSTITUTE OF INNOVATION FOUNDATION

INSTYTUT Innowacji

TALISMAN ENERGY



Case Studies

1. Social Impact Assessment

2. Good Neighbour Program

3. Canadian Wonders
– English Language Project

GOOD NEIGHBOUR PROGRAM

- The Good Neighbour Program (GNP) adds consistency, process and practical approach to managing our risk across our North America and Poland operations
- The GNP addresses the need to proactively address and mitigate these impacts to reduce stakeholder risk and maintain our social and regulatory licence to operate
- The GNP has been successfully implemented in USA, Canada and Poland
- The GNP is a field based initiative

good neighbour

GOOD NEIGHBOUR PROGRAM – Key Points

- **Key Commitments:**
  - Roads – Speed, traffic, school bus schedules
  - Dust- Dust control for roads in close proximity to residences
  - Noise - No Retarder/Jake brakes within town limits
  - Weeds - Assess existing weeds, undertake weed control
  - Lease Maintenance - Controlling litter on lease sites, roads

TALISMAN ENERGY

good neighbour

SHALE GAS CHALLENGES – LOCAL IMPACT

- Engage early and often with local stakeholders to build strong relationships
- Talk about and address key public and government concerns:
  - Water conservation and safe disposal
  - Nature, frequency and duration of surface impacts
  - Noise levels and transportation effects
  - Economic benefits
- Continuous dialogue between government, industry & communities

good neighbour

WE WANT TO BE LOCAL ...





WE ACT LOCAL...




Case Studies

1. Social Impact Assessment

2. Good Neighbour Program

3. Canadian Wonders – English Language Project

CANADIAN WONDERS English Language Project

The major disadvantage of local – rural communities in Poland is poor access and availability to education and especially experiences of other regions and countries with inter- cultural challenges.

This project is held in concession areas of the Talisman Energy in Poland: children and youth have a unique opportunity to learn canadian culture, economy and style of live – in English language courses flavored with some Canadian tastes.

The project is an example of tri-sector cooperation including local authorities, an NGO and commercial partners.

CANADIAN WONDERS – stakeholder matrix

- induction
- financing
- promotion

Talisman Energy Polska

Institute of Innovation

- promotion
- coordination
- implementation

PCCC

patronage / project's promotion among PCCC members

TEP Employees VOLUNTARY

teaching single lessons

Canadian Embassy

contacts providing (Canadian educational centers) / materials suggestion / brochures providing / support in organization a trip to Warsaw for students

Local Teachers

course materials preparing, teaching

Braniewo Center of Culture / Local School in Gortatowo

- patronage
- classroom providing
- support with teachers' candidates searching
- support in project coordination (lessons and fee collection)

CANADIAN WONDERS

Embassy of Canada / Ambassade du Canada

UL Matejki 1/5
00-481 Warszawa

October 3, 2011

Talisman Energy Polska
Warsaw Financial Centre
Emilii Plater 53
00-113 Warsaw

Dear Students of the Canadian English Teaching program in Braniewo,

I write to welcome you to an excellent initiative organised in Braniewo by Talisman Energy Polska: the Canadian English Teaching program. While this program has no formal affiliation with the Government of Canada or its Embassy here in Warsaw, I must say that I was interested and pleased to learn from our colleagues at Talisman, an associate of one of Canada's largest and most important global energy firms, of this new program of English-language instruction set in the context of the history, geography, culture and people of Canada, which I understand has been tailored specifically for you.

I congratulate you all in advance for your interest in learning or improving your English, and hope that the knowledge and understanding of Canada you acquire in this process will lead to the development of greater interest in and exposure to Canada for you and your friends, families and classmates in days ahead. I wish you all the best with your studies, and with the joy and discovery and fun of learning together.

Yours sincerely,

Daniel Costello
Ambassador of Canada to Poland

Canada

CANADIAN WONDERS – STUDENTS TRIP TO WARSAW
Lesson about Canada, 23 January 2012

Voluntary engagement of TEP's employee – Hernan Rodriguez, HSE - lesson with native speaker of English, presentation about Canada

CANADIAN WONDERS - DO YOU KNOW ?

Sports of Canada – Hockey ?

LACROSSE: A game originating from the Aboriginals of Canada and has recently regained mass popularity across North America. It is the official national sport of Canada.

Our learnings to share with you:

KEY LEARNINGS FOR OPERATORS

- **LEARN**
  about the concession region
  – people, nature, concerns...
  – do SIA
- **ENGAGE** early and often with local stakeholders –
  to build strong relationships
- **TALK** about and address key public and government concerns:
  - Water conservation and safe disposal
  - Nature, frequency and duration of surface impacts
  - Noise levels and transportation effects
  - Economic benefits
- Continuous **DIALOGUE** between government, industry & communities

THE OPERATORS ROLE

Local Communities' Voices

Short movie presents interviews with local leaders, farmers, fire-brigade officers – all those who had been affected by the geophysical and geological works related to shale gas exploration operations in Talisman Energy-San Leon concessions in Poland in 2012.

THANK YOU!

tgryzewski@talisman-energy.com
tgryzewski@gmail.com

Tomasz A. Gryżewski
Corporate Affairs Director

TALISMAN ENERGY

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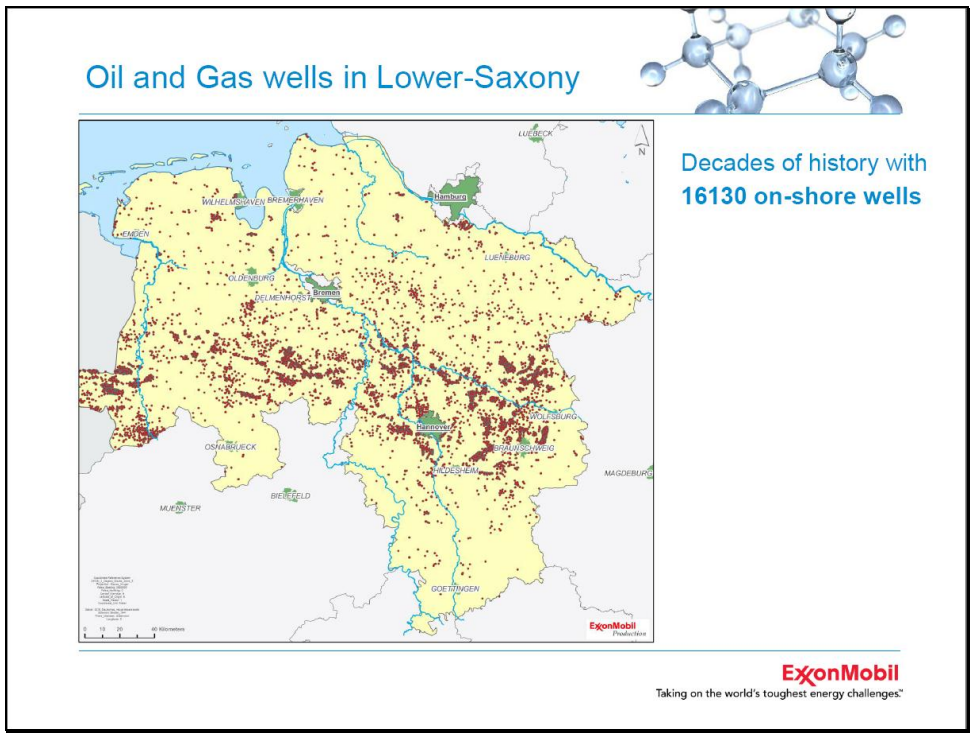
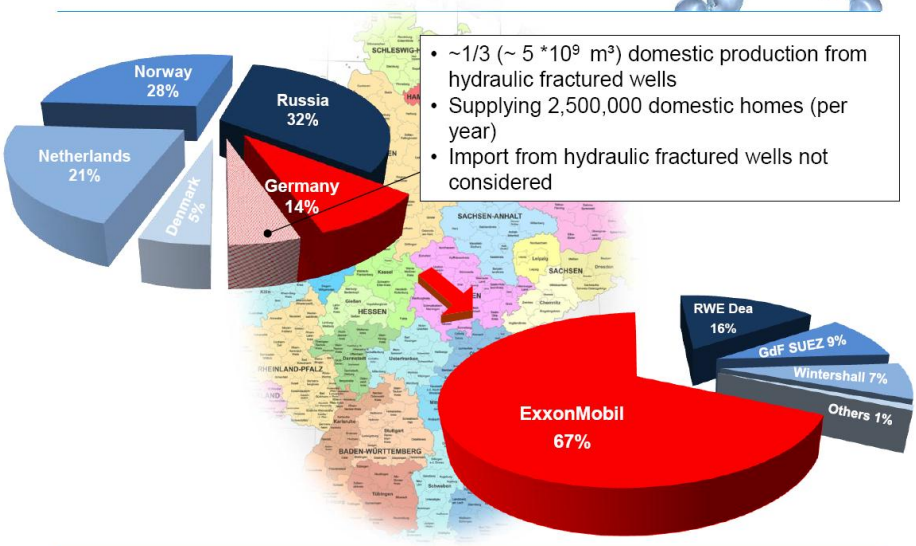
11.18 Good practices on social and community engagement

Nikolaas BAECKELMANS, ExxonMobil

11.18.1 Presentation



German Natural Gas Supply (2011)

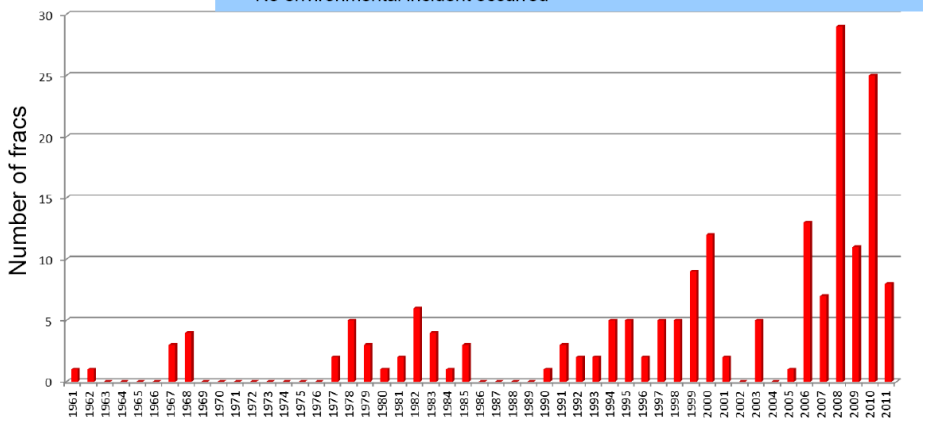


- ~1/3 (~ 5 *10^9 m^3) domestic production from hydraulic fractured wells
- Supplying 2,500,000 domestic homes (per year)
- Import from hydraulic fractured wells not considered

ExxonMobil
Taking on the world's toughest energy challenges.

50 Years of Frac-Operations in Germany

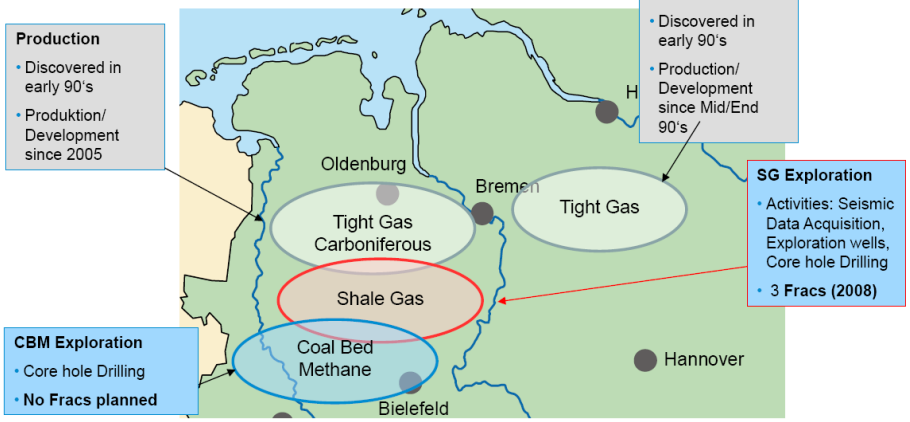
- In Germany frac technology has been executed more than 300 times
- No environmental incident occurred



ExxonMobil
Taking on the world's toughest energy challenges.

Exploring for new reserves

Tight Gas reservoirs have been developed in NW-Germany since more than 20 years



ExxonMobil
Taking on the world's toughest energy challenges.

Year 2008/09: EM plans were well received

US-Riese will das Gas aus der Tiefe

Künstliche Haarrisse sollen den Rohstoff nach oben fördern

02.10.2009, 09:56

Fossile Brennstoffe

Der Gas-Scheich von Hannover

Niedersachsens Ministerpräsident Christian Wulff hat allen Grund zum Jubeln. Neue Ölquellen kann sein Land zwar nicht vorweisen – möglicherweise lässt sich aber schon bald ein anderer Rohstoff zu Geld machen.

In Niedersachsen existieren möglicherweise große unerschlossene Erdgas-Vorkommen. Der weltgrößte Erdöl- und Erdgaskonzern Exxon Mobil aus dem US-Bundesstaat Texas will deshalb einen dreistelligen Millionenbetrag für die Erforschung dieser Vorräte investieren, wie Ministerpräsident Christian Wulff (CDU) am Donnerstag (Ortszeit) in Houston mitteilte. Wulff ist in den USA noch bis Sonntag mit einer 50-köpfigen Wirtschaftsdelegation aus

Der niedersächsische Ministerpräsident Christian Wulff (CDU)

MP Wulff in USA
Millionen-Deal mit Öl-Multi
Exxon sucht in Niedersachsen nach Gas

ExxonMobil
Taking on the world's toughest energy challenges.

2008-2011 first wells: positive media & community reactions

Lower Saxony: Damme - SG

NRW: Oppenwehe- SG

Bad Laer/Osnabruck CBM

New Situation: Lünne 1/1a

- SG well drilled in 2011
- Planned fracking operations on hold

Spill over to Conventional Production: Bötersen Z11

Erste Demo gegen Fracking

Bürgerinitiative organisiert Protest

Soltrum (dim). Am Freitag haben sich etwa 150 Menschen aller Altersgruppen an der Bohrstelle bei Jerchel versammelt, um gegen Exxon Mobil und deren Gasbohren mit „Fracking" zu protestieren. Das Bürgerinitiative (BI) „Frack-loses Gasbohren" hatte

Kundgebung am Bohrloch

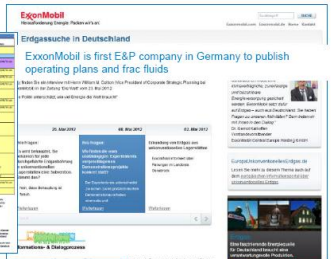
sbohren" trifft sich kurz vor der Jahreswende in Bötersen / Zeichen des Widerstandes

Information and Dialogue

Early, open, and proactive information of the local citizens :

- Preliminary talks with mayor(s)
- Round Table with authorities involved
- Info Market
  - Press
  - Politics
  - Public

- Information and Dialogue Process
- Info-Mobil
- Advertising campaigns - regional and nationwide
- Internet presence: www.erdgassuche-in-deutschland.de



Info-Mobil with local citizens

Production

Public information and dialogue process

Process facilitators: Ruth Hammerbacher und Christoph Ewen

Work group of social actors

- *Communities*
- *Group of residents and interest groups*
- *Water authorities*
- *Environmental groups*
- *Churches*
- *Trade Associations etc.*

Neutral Body of Experts

Scientific Coordinator: Water Conservation/ Ecosystem analysis:
Prof. Dr. Dietrich Borchardt
Helmholtz Centre for Environmental Research

Geology/ Hydrogeology:
Prof. Dr. Martin Sauter
University of Göttingen

Multi-phase flow in the subsurface:
Prof. Dr. Rainer Helmig
University of Stuttgart

Environmental Chemistry/ Drinking Water:
Prof. Dr. Fritz Frimmel
Karlsruhe Institute of Technology

Toxicology/Bioanalytical Ecotoxicology:
PD Dr. Rolf Altenburger
Helmholtz Centre for Environmental Research

Risk Assessment and Water Rights:
Prof. Dr. Alexander Roßnagel
University of Kassel

Human Toxikology:
Prof. Dr. Ulrich Ewers
Institute for Environmental Hygiene and Toxicology

Plant Safety:
Dr. Hans-Joachim Uth
Formerly German Federal Environment Agency

Demonstration/Pilot- Projects

- Building multiple show-cases at early exploration stage
  - Demonstration of safe and prudent operations
  - Executing monitoring programs (e.g Groundwater, Seismicity, Fracture-Geometry)
  - Integration of scientific research programs (e.g. long-term cement integrity, Methane diffusivity)
  - Participation of local residents & communities
- Main Focus on UG activities but considering additional conventional pilot- projects (e.g test of improved frac chemicals, material flow balances)

12

ExxonMobil
Taking on the world's toughest energy challenges™

11.19 Chemical disclosure of hydraulic fracturing fluids: an industry response

Malcolm RICE-JONES, OGP

11.19.1 Abstract

The International Association of Oil and Gas Producers (OGP) is committed to progressing scientific fact based debate and is therefore happy to facilitate the voluntary disclosure of chemicals used in hydraulic fracturing of European shale gas wells. This presentation gives an overview of the shale gas extraction process and the safeguards built into it before describing the Hydraulic Fracturing Fluid and Additive Component Transparency Service (FACTS) that OGP is proposing. Progress on developing this web based tool to date as well as expected activity over the next few months are discussed along with potential future developments.

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11.19.2 Presentation

OGP

Public disclosure of chemicals used in hydraulic fracturing

Joint Research Centre's Workshop;
Shale Gas in Europe
Amsterdam 8th March

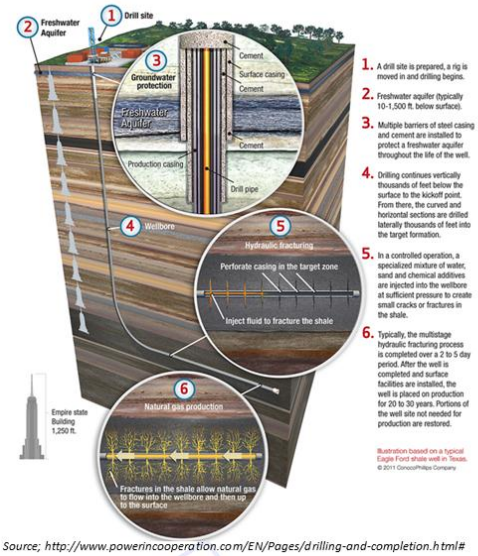
OGP represented by
Malcolm Rice-Jones

Since 1974 …

OGP

- OGP represents publicly traded, private and state oil & gas companies, field service companies & industry associations
- Members produce more than half of the world's oil and over one third of its gas
- Offices in London and Brussels
- Sharing experience, debating emerging issues & promoting cooperation, consistency and effectiveness
- Facilitating continual improvement in HSE, CSR, engineering and operations

A reminder of the basics



Source; http://www.powerincooperation.com/EN/Pages/drilling-and-completion.html#

- Typical European shale formations are greater than 3 km below the aquifer
- Multiple layers of impervious rock separate the shale formation from the aquifer
- Prior to selecting well locations, surface hydrology and subsurface geology are examined in detail
- Use air or freshwater based fluids when drilling through freshwater zones
- Design and construct wells with at least two barriers
- Install surface casing to depths below freshwater aquifers and cement to surface
- Pressure test casing/cement and monitor wellbore integrity

OGP welcomes the opportunity for constructive dialogue

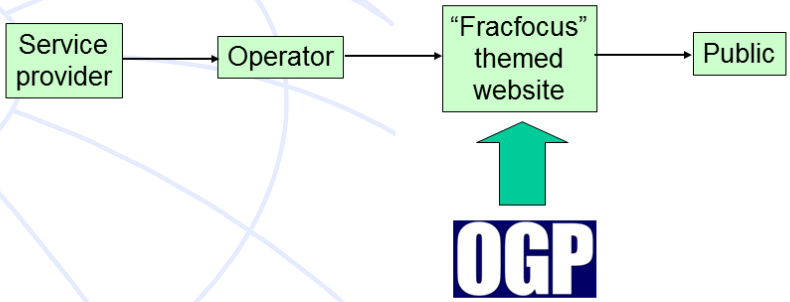
Typical chemical substances used in hydraulic fracturing

Compound	Pupose	Common application
Acids	Helps disolve minerals and initiate fissure in rock (pre-fracture)	Swimming pool cleaner
Sodium Chloride	Allows a delayed breakdown of the gel polymer chains	Table salt
Polyacrylamide	Minimizes the friction between fluid and pipe	Water treatment, soil conditioner
Ethylene Glycol	Prevents scale deposits in the pipe	Automotive anti freeze, deicing agent, household cleaners
Sodium/Potassium Carbonate	Maintains effectiveness of other components	Washing soda, detergent, soap, water softner, glass, ceramics
Glutaraldehyde	Eliminates bacteria in the water	Disinfectant, sterilization of medical and dental equipment
Guar Gum	Thickens the water to suspend the sand	Thickner in cosmetics baked goods, ice cream, toothpaste, sauces
Citric Acid	Prevents precipitation of metal oxides	Food additive; food and beverages; lemon juice
Isopropanel	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, hair colouring

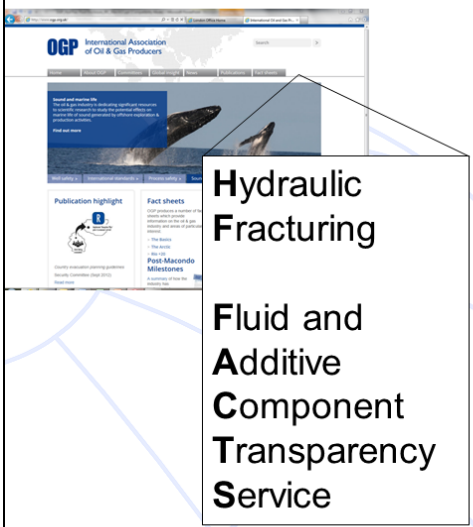
Chemicals typically form less than 1% of hydraulic fracturing fluid

- **OGP supports transparency and dialogue**
- **In addition to regulatory requirements, OGP is encouraging members to make a public disclosure of chemicals used in hydraulic fracturing**
  - **will make an important contribution to scientific, fact based dialogue regarding the development of shale gas reserves**

The information flow



A simple, easy to implement, public website is appropriate at this stage



Hydraulic
Fracturing

Fluid and
Additive
Component
Transparency
Service

- **To cover shale directed, hydraulically fractured wells in the European Economic Area**
  - Potential to extend to other countries
- **OGP members will be able to participate on a voluntary basis**
  - others welcome to join if they commit to providing timely and accurate data
- **Information, as per "fracfocus" in pdf format to be submitted by the operator to OGP**
  - Name of operator
  - Location of well
  - Well depth
  - Total volume of water used
  - Chemical usage – maximum ingredient concentration (% by mass)
- **Access via the OGP website**
  - Searchable by country
- **Complementary to other initiatives**

Progress to date

- **Internal OGP resources identified for system development**
- **System design confirmed**
- **Development ready to start once format of the input form has been clarified**
- **Extensive reviews with service providers:**
  - **Ensure maximum disclosure consistent with protecting proprietary information sufficiently to encourage innovation**
    - Linkage to CAS retained
- **Additional consultations with national bodies**
  - **Ensure consistency**

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International Association of Oil and Gas Producers (OGP)
Natural Gas from Shale (NGS) Wells
Shale Gas Well - Hydraulic Fracturing Fluid and Additive Component Transparency Service (HF FACTS)

Well Location		Well Description		Hydraulic Fracturing Fluid Data	
Country		Operator of Well		Water Volume (1) (Cubic Metres)	11,389.6908
Latitude		Name of Well		Max mass % of Total HF Fluid	86.94171%
Longitude		DECC Well Registration No		Propant (kilograms)	1,515.9938
Long/Lat projection		HF Completion Date		Max mass % of Total HF Fluid	11.57214%
County		Well Depth (TVD Meters)		% of Water Volume - recycled/produced water	N/A
Regulator Consents		Avge frac perf depth (TVDm)		% of Water Volume - fresh water	N/A
EIA Permit No				Max (mass %) Water+Proppant=	98.51385%
Local Planning consent					
Hydraulic Fracture Programme approval					

HF Fluid Products

Product Trade Names in Fracturing Fluid (if applicable)	Product Purpose in Well	Supplier(s)
A201, A264, B244B, D206, F112, H015, H036, H075, J218, J353L, J481, J511, J579, J580, J604, L058, L064, L065, U028, U042, W054, B351-2040, S012-3050, S012-2040	Inhibitor Aid , Corrosion Inhibitor, Bactericide, Antifoam Agent, Surfactant , Acid, Breaker, Stabilizing Agent, Additive, Gelling Agent, Crosslinker, Iron Control Agent, Clay Control Agent, Scale Inhibitor, Activator, Chelating Agent, Demulsifier, Propping Agent	Schlumberger

HF Fluid Constituents

Chemical Substance in Fracturing Fluid (2)	Chemical Abstract Service Number (CAS Number) (3)	Maximum Chemical substance Mass % in HF Fluid (4)	Comments
Crystalline silica	14808-60-7	11.57214%	
Hydrogen chloride	7647-01-0	0.48424%	
Guar gum	9000-30-0	0.28647%	
Polylactide resin	9051-89-2	0.16029%	

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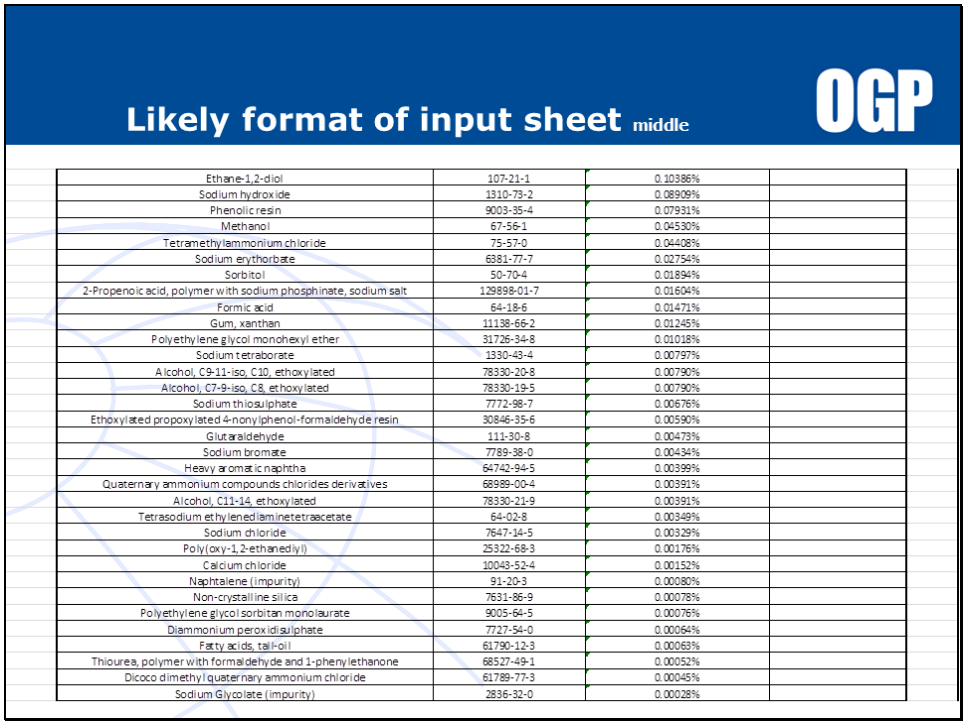

Ethane-1,2-diol	107-21-1	0.10386%	
Sodium hydroxide	1310-73-2	0.08909%	
Phenolic resin	9003-35-4	0.07931%	
Methanol	67-56-1	0.04530%	
Tetramethylammonium chloride	75-57-0	0.04408%	
Sodium erythorbate	6381-77-7	0.02754%	
Sorbitol	50-70-4	0.01894%	
2-Propenoic acid, polymer with sodium phosphinate, sodium salt	129898-01-7	0.01604%	
Formic acid	64-18-6	0.01471%	
Gum, xanthan	11138-66-2	0.01245%	
Polyethylene glycol monohexyl ether	31726-34-8	0.01018%	
Sodium tetraborate	1330-43-4	0.00797%	
Alcohol, C9-11-iso, C10, ethoxylated	78330-20-8	0.00790%	
Alcohol, C7-9-iso, C8, ethoxylated	78330-19-5	0.00790%	
Sodium thiosulphate	7772-98-7	0.00676%	
Ethoxylated propoxylated 4-nonylphenol-formaldehyde resin	30846-35-6	0.00590%	
Glutaraldehyde	111-30-8	0.00473%	
Sodium bromate	7789-38-0	0.00434%	
Heavy aromatic naphtha	64742-94-5	0.00399%	
Quaternary ammonium compounds chlorides derivatives	68989-00-4	0.00391%	
Alcohol, C11-14, ethoxylated	78330-21-9	0.00391%	
Tetrasodium ethylenediaminetetraacetate	64-02-8	0.00349%	
Sodium chloride	7647-14-5	0.00329%	
Poly(oxy-1,2-ethanediyl)	25322-68-3	0.00176%	
Calcium chloride	10043-52-4	0.00152%	
Naphtalene (impurity)	91-20-3	0.00080%	
Non-crystalline silica	7631-86-9	0.00078%	
Polyethylene glycol sorbitan monolaurate	9005-64-5	0.00076%	
Diammonium peroxidisulphate	7727-54-0	0.00064%	
Fatty acids, tall-oil	61790-12-3	0.00063%	
Thiourea, polymer with formaldehyde and 1-phenylethanone	68527-49-1	0.00052%	
Dicoco dimethyl quaternary ammonium chloride	61789-77-3	0.00045%	
Sodium Glycolate (impurity)	2836-32-0	0.00028%	

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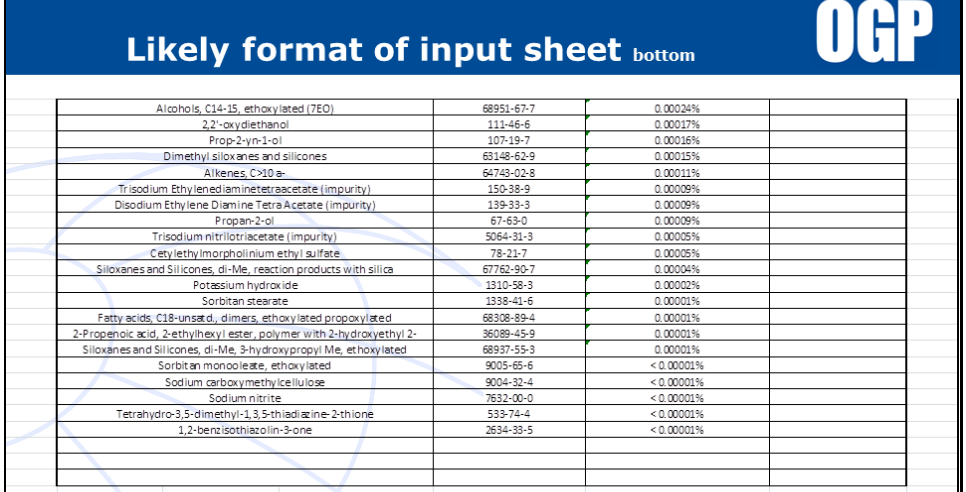

Alcohols, C14-15, ethoxylated (7EO)	68951-67-7	0.00024%	
2,2'-oxydiethanol	111-46-6	0.00017%	
Prop-2-yn-1-ol	107-19-7	0.00016%	
Dimethyl siloxanes and silicones	63148-62-9	0.00015%	
Alkenes, C>10 a-	64743-02-8	0.00011%	
Trisodium Ethylenediaminetetraacetate (impurity)	150-38-9	0.00009%	
Disodium Ethylene Diamine Tetra Acetate (impurity)	139-33-3	0.00009%	
Propan-2-ol	67-63-0	0.00009%	
Trisodium nitrilotriacetate (impurity)	5064-31-3	0.00005%	
Cetylethylmorpholinium ethyl sulfate	78-21-7	0.00005%	
Siloxanes and Silicones, di-Me, reaction products with silica	67762-90-7	0.00004%	
Potassium hydroxide	1310-58-3	0.00002%	
Sorbitan stearate	1338-41-6	0.00001%	
Fatty acids, C18-unsatd., dimers, ethoxylated propoxylated	68308-89-4	0.00001%	
2-Propenoic acid, 2-ethylhexyl ester, polymer with 2-hydroxyethyl 2-	36089-45-9	0.00001%	
Siloxanes and Silicones, di-Me, 3-hydroxypropyl Me, ethoxylated	68937-55-3	0.00001%	
Sorbitan monooleate, ethoxylated	9005-65-6	< 0.00001%	
Sodium carboxymethylcellulose	9004-32-4	< 0.00001%	
Sodium nitrite	7632-00-0	< 0.00001%	
Tetrahydro-3,5-dimethyl-1,3,5-thiadiazine-2-thione	533-74-4	< 0.00001%	
1,2-benzisothiazolin-3-one	2634-33-5	< 0.00001%	

Notes:

(1) Water utilized may be any combination of recycled water, produced water or fresh water.

(2) All chemical additive substance data is provided by suppliers and is consistent with Material Safety Data Sheets.

(3) See www.echa.europa.eu to find ECHA numbers; blank if confidential business information but regulator fully appraised.

(4) Because maximum percentages are shown, total of water, proppant and HF chemical substance components may be greater than 100%.

Possible link to FracFocus

- On going discussions with Fracfocus
  - Ground Water Protection Council
  - Interstate Oil and Gas Compact Commission
- Potential to implement an upgrade to the OGP system in 2014 which would be a European focused variation of version2.0 due for release, late 2013
  - Data entry and search capability
  - Educational information

An opportunity to provide information on shale gas in general

- Links to educational aspects of fracfocus
- Links to OGP fact sheets
- Whether/how to establish an EU educational site will be a separate decision once the disclosure site is up and running.

Way forward

2013	Feb	Mar	Apr	May	June
Agree final OGP HF FACTS input form					
Update system architecture in OGP website to provide for disclosure on-line					
Gather additional data and gain commitment to utilize the site					
Beta test the system with real data and debug					
Launch the OGP on line disclosure site					

- **Annual reviews to ensure that;**
  - **Integrity of the data is good**
  - **The functionality is consistent with the volume of data submitted**
  - **Appropriate changes are made and implemented, e.g.**
    - Improved searchability
    - Expanded geographic coverage
  - **Appropriate linkage to ECHA/REACH has been established**

Thank you for your attention

Contact:

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Michael.Engell-Jensen@ogp.org.uk

Rachel Bonfante

Rachel.Bonfante@ogp.be

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11.20A Ukrainian platform for shale gas: Kyiv Unconventional Gas Institute

Anton ANTONENKO, DiXi Group

11.20.1 Abstract

The presentation provides background information on the expected unconventional gas reserves in Ukraine and also on the progress with development of these resources. It also addresses main public and political concerns voiced and campaigns held. Presentation informs about the idea of Kyiv Unconventional Gas Institute, key events carried out and elaborates on the online platform developed to promote the dialog between stakeholders to the next level.

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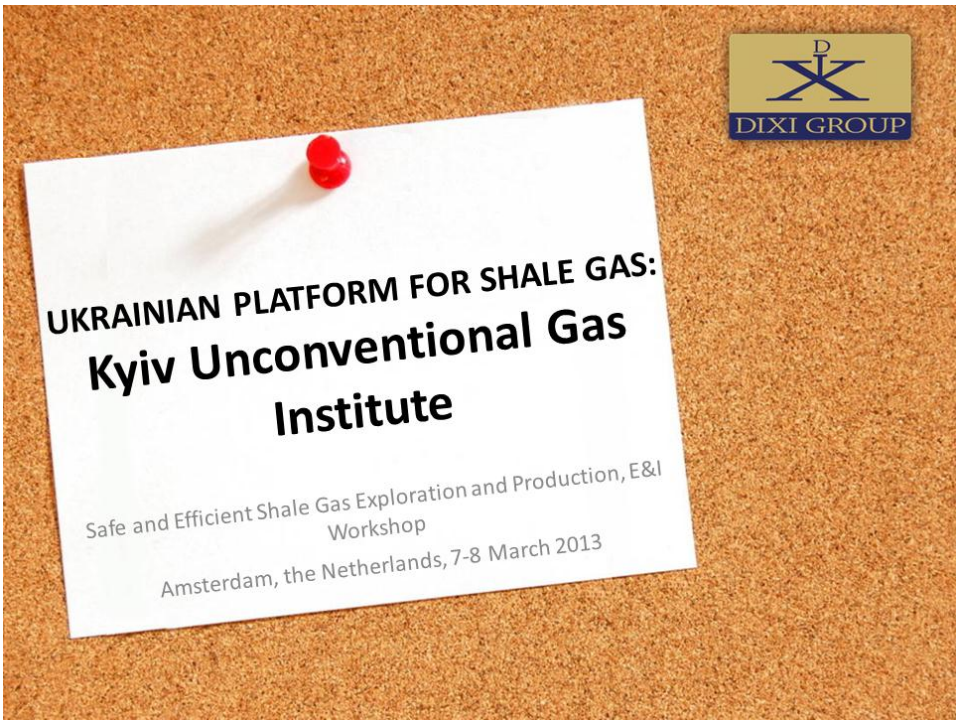
11.20.2 Presentation



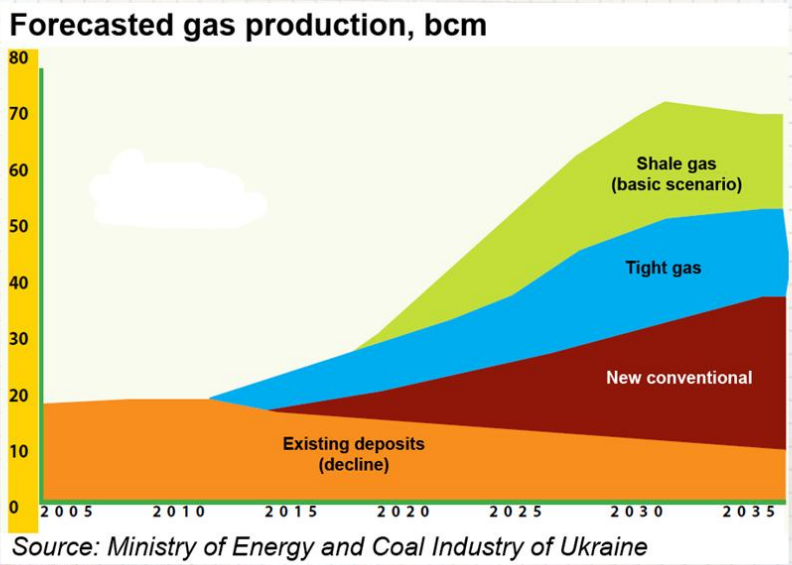
DiXi Group is…

- **Ukrainian market overview**
  - Expected unconventional resources
  - Current projects' progress
- **Main concerns raised and campaigns held**
- **Ideas to address concerns and campaigns**
  - Kyiv Unconventional Gas Institute

Ukrainian market overview

Expected unconventional resources

Gas Production



Source: Ministry of Energy and Coal Industry of Ukraine

Forecasted unconventional gas production in Ukraine, bcm

Source	Year	Shale gas	Tight gas	Coalbed methane
Draft reviewed Energy Strategy (2012)	2030	6-11	7-9	2-4
IHS CERA (2012)	2025		9	
	2035	25-30	16	
IRG (2012)	2020		22	
	2035		97	
Institute for Economics and Forecasting, National Academy of Sciences (2011)	2030	7.5		

Ukrainian market overview

Current projects' progress

Developments

May 10, 2012 – Shell and Chevron won the PSA tenders for Yuzivska and Oleska fields respectively

Developments

October 25, 2012 – Shell and state company UkrGazVydobuvannya, first well

Developments

January 16-17, 2013 – Donetsk and Kharkiv regional councils approve the draft PSA

Oleg Proskuryakov,
Minister for Environment and Natural Resources of Ukraine

"in **5-6 years** – **several bcm**/year,

in **15 years** – **20 bcm**"

Developments

January 21, 2013 – Government approves the draft PSA

January 25, 2013 – The "shale agreement" for Yuzivska field signed

Developments for Oleska field

Pending approvals from local councils;

Chevron conducts public hearings;

Minister hopes for approval in the nearest future

Other companies

Eni bought 50,01% in ZakhidGazInvest company, license holder for 9 deposits;

ExxonMobil signed preliminary agreement with state holding Naftogaz in 2011;

TNK-BP expressed interest in extractive projects;

More tenders planned for 2013 (Slobozhanska field, Poltava-Dnipropetrovsk-Donetsk field etc)

Main concerns raised and campaigns held

Public Concerns


Drinking water contamination;


Seismic risks;


Population density;


Allusions to Chernobyl;


Spill-out of fracking chemicals;


Transparency issues;


"Foreign interest" issue;


"Land compensation" issue;


Soviet heritage of environmental problems;

Public Campaigns

- **National Platform** against unconventional gas exploration and production;
- Staging **protests during public hearings** and meetings;
- Holding **press conferences** and other events to voice the position;
- Engagement of **politicians** into the process.

Political Support

ПАРТІЯ РЕГІОНІВ	Батьківщина	ПАРТІЯ УДАР ВІТАЛІЯ КЛИЧКА	СВОБОДА	КОМПАРТІЯ УКРАЇНИ
208 MPs	99 MPs	42 MPs	36 MPs	32 MPs
YES	?	YES	?	NO
	Changing position from moratorium to increased env. safety	If environental demands are observed	Changed position from moratorium to increased env. safety	

Political Concerns

Draft Law on unconventional gas moratorium registered in the Parliament and later withdrawn

New draft law on stricter regulation registered instead

Draft Resolution of Parliamentary Hearings on Environmental Safety registered

UCG Used as Part of Larger Geopolitical Game

It became political issue and one of the tools for geopolitical impact from outside the country

Ideas to address concerns and campaigns

Platform for:

- **Research** projects
(conditions, technologies, possible outcomes)

- **Communication & Information**
(communities, journalists, politicians)

- **Expert Knowledge Transfer**

- **Education**

Research Projects

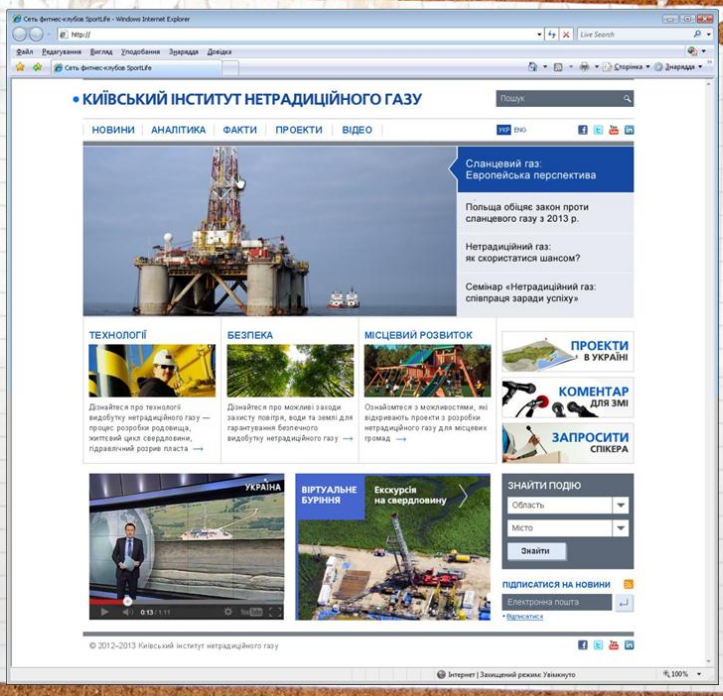
Unconventional Gas: How to Use the Chance;

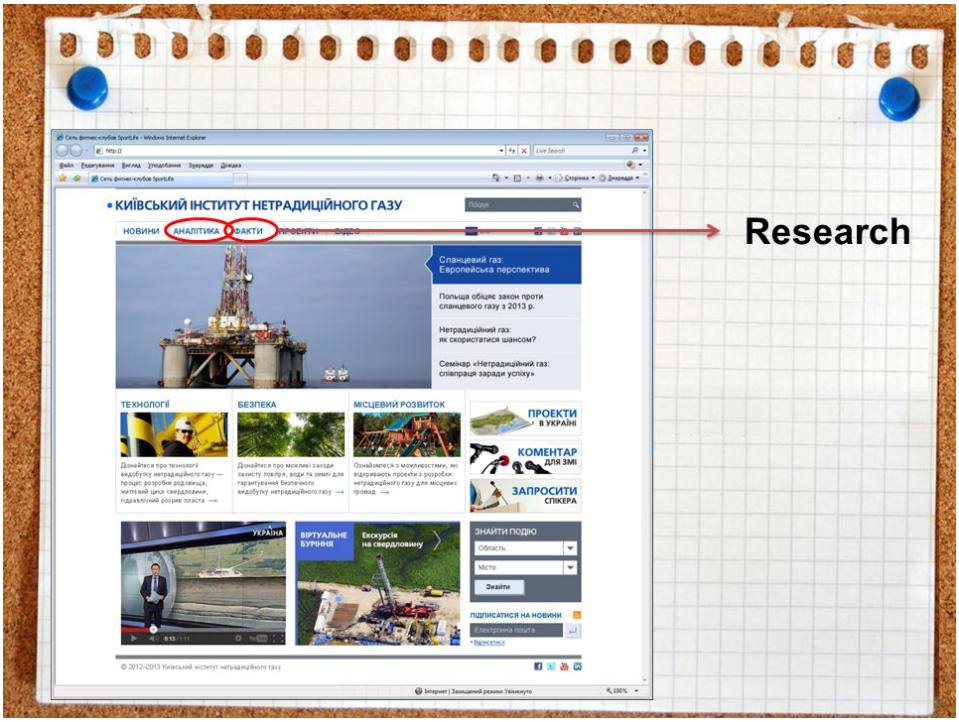
Country Studies “Society and Unconventional Gas Extraction: experience” (USA, Poland, UK)

Communication & Information

September 2012 – 2-day **seminars for journalists and environmentalists** on UCG basics;

2012 – **study tours and participation in conferences**

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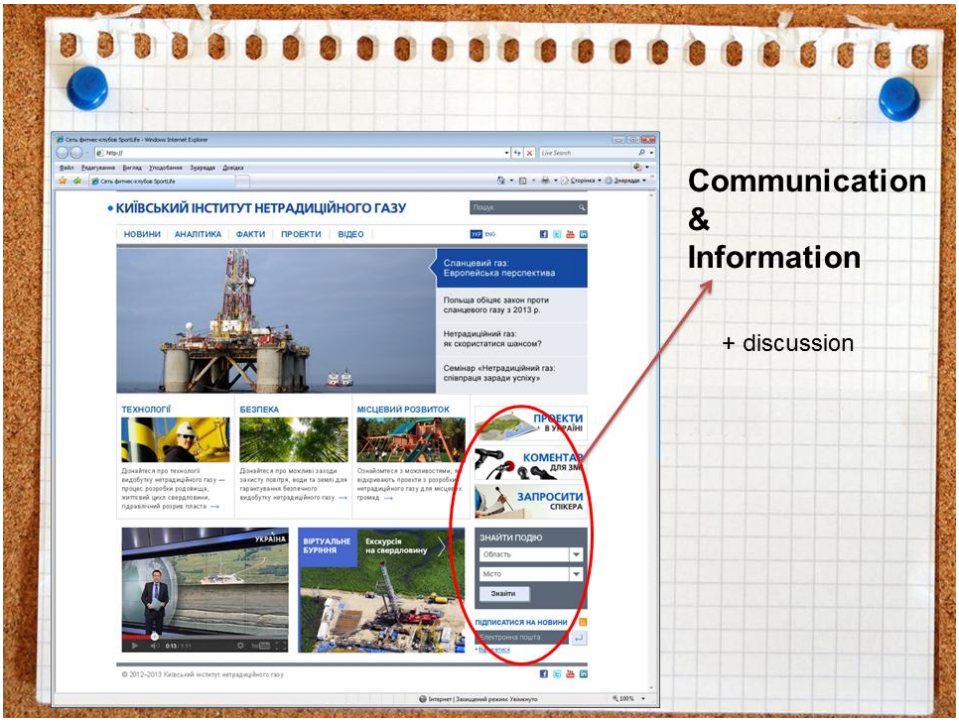
Research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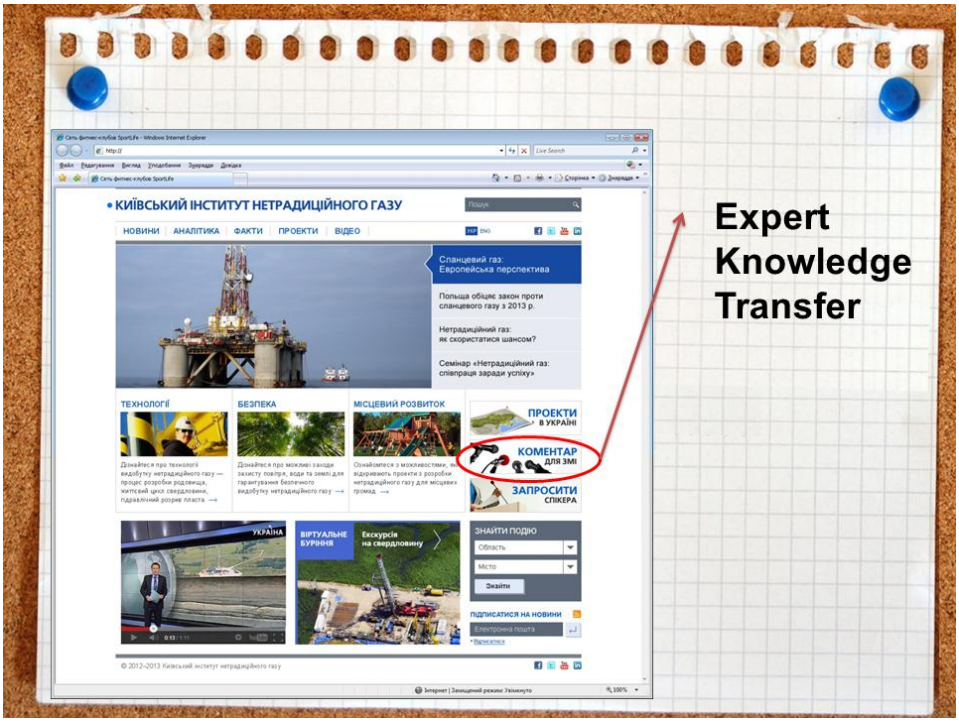
Communication & Information
+ discussion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Польща обіцяє закон проти сланцевого газу з 2013 р.
Нетрадиційний газ: як скористатися шансом?
Семінар «Нетрадиційний газ: співпраця заради успіху»
ТЕХНОЛОГІЇ
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Екскурсія на свердловину
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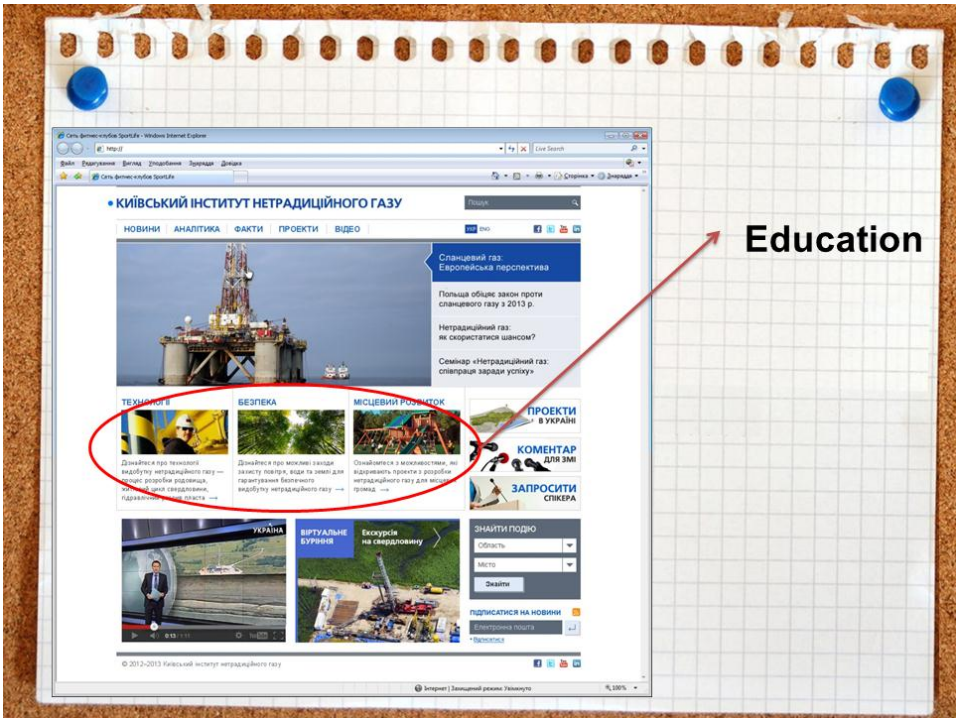
ПІДПИСАТИСЯ НА НОВИНИ
Expert Knowledge Transfer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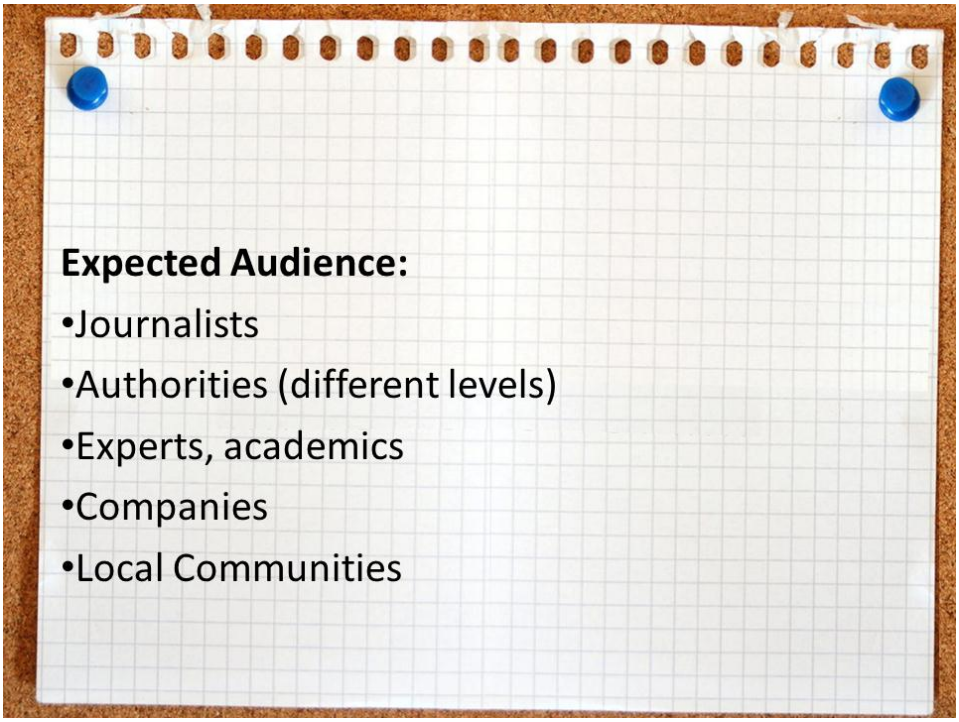
ПІДПИСАТИСЯ НА НОВИНИ
Education


Expected Audience:
•Journalists
•Authorities (different levels)
•Experts, academics
•Companies
•Local Communities


THANK YOU
DIXI GROUP
Anton Antonenko
antant@dixigroup.org

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11.21 European Platform on Shale Gas

Arne ERIKSSON & Michael SCHUETZ

11.21.1 Presentation

European Parliament report on unconventional hydrocarbons, drafted by MEP Tzavela and adopted on 21 November 2012

highlighted the importance of creating:

"… independent platforms composed of industry and science representatives aiming to provide opinions and establish good practices…".

3

JRC takes this opportunity to propose a discussion to explore the viability of such platform

- *see send-out*

4

Already picked up during the workshop

- *Data (common format for gathering, storing sharing)*
- *Methods, peer-reviewed, robust*
- *Facilities*
  - *Wells for research, developed by industry*
  - *open to controlled research – "natural labs"*

5

Forward Looking

- Working Together

Bridging The Gaps

- Prioritization, Data, Methods
- Dialogue among Stakeholders

What do authorities, industry and citizens ask for?

(risk & reward)

5 April 2013

6

Discussion

- ***Questions to answer?***
- ***Objectives, goals***
- ***Type of activities***
- ***Participation***
- ***Governance / hosting***

7

European Commission
EUR 25990 – Joint Research Centre – Institute for Energy and Transport

Title: WORKSHOP PROCEEDINGS: SAFE AND EFFICIENT SHALE GAS EXPLORATION AND PRODUCTION

Editors: ARNE ERIKSSON, LUCA GANDOSSI, PETER ZENIEWSKI

Luxembourg: Publications Office of the European Union

2013 – 262 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424 (online)

ISBN 978-92-79-30642-6 (pdf)

doi: 10.2790/77620

Abstract

The European Commission's Joint Research Centre – Energy Security Unit, in cooperation with the Directorate-General for Energy, organised an Enlargement and Integration Workshop on "Safe and Efficient Shale Gas Exploration and Production: Best available technologies and R&D projects for Europe". The workshop took place in Amsterdam (the Netherlands) on 7-8 March 2013.
The main objectives of the workshop were twofold: to present and discuss ongoing and planned European research, development and demonstration projects; and to explore the interest in, and viability of a European Platform for Shale Gas Development. The participants consisted of, in equal parts, representatives from industry, geological surveys, academia and European Commission officers, involved in European unconventional oil and gas development and research.
Presentations were given on European research, development and demonstration projects covering a broad spectrum of technical, social and environmental issues related to safe and efficient shale gas development in Europe. Discussions on state of the art, best practices, R&D results and gaps as well as possible needs for demonstration projects were conducted, as well as the need of bringing together industry and research representatives in a structured dialogue, sharing information, reviewing R&D needs and communicating with policy makers.
This report summarises the main conclusions from the Workshop and includes the presentations that were given by the invited Speakers.

LD-NA-25990-EN-N

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

Publications Office

ISBN 978-92-79-30642-6

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